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ABSTRACT

This report presents information for identification of the national trends in the amount, age, loss, condition, and perceived adequacy of academic research equipment in selected science and engineering fields. The data were obtained from a stratified probability sample of 55 colleges and universities and from a separately selected sample of 24 medical schools. Discussions are included on these trends: (1) by type of institution; (2) physical and environmental sciences; (3) engineering, computer science, and materials science; and (4) biological and agricultural sciences. Included are data related to the amount of academic research equipment, fund sources for the equipment, quality of the equipment, patterns of equipment usage, and maintenance and repair of the equipment. Appendices include technical notes, tables, a questionnaire, data sheets, adjustment methodology, sampling errors, and trends in numbers of institutions. (YP)

Academic Research Equipment in Selected Science/Engineering Fields: 1982-83 to 1985-86

National Science Foundation

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ACADEMIC RESEARCH EQUIPMENT
IN SELECTED
SCIENCE ENGINEERING FIELDS:
1982-83 TO 1985-86

Prepared for:

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Division of Science Resources Studies
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TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

LIST OF TABLES (continued)

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The 1985-86 National Survey of Academic Research Instruments and Instrumentation Needs was designed and conducted by Westat, Inc. under the sponsorship and direction of the Universities and Colleges Studies Group, Division of Science Resources Studies of the National Science Foundation (NSF). The research was conducted under NSF Contract No. SRS-8608637. At NSF, James Hoehn, Judy Coakley, Charles Dickens, and William Stewart provided oversight and guidance during the survey.

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EXECUTIVE SUMMARY

Introduction

This report presents information from the National Science Foundation's (NSF's) National Survey of Academic Research Instruments and Instrumentation Needs. The survey program is designed to identify national trends in the amount, age, cost, condition, and perceived adequacy of academic research equipment in selected science/engineering (S/E) fields. In 1986, information was collected about equipment in place at the end of 1985 in the physical and computer sciences and engineering. Similar data were collected in 1987 regarding the 1986 stock of research equipment in the agricultural, biological, and environmental sciences. The survey encompassed all research equipment originally costing $10,000 to $1 million. The data were obtained from a stratified probability sample of 55 colleges/universities selected from among the 174 largest R&D performers in the nation (excluding medical schools), and from a separately selected sample of 24 institutions selected from among the 92 largest medical school recipients of NIH research grants. Similar data were collected three years earlier regarding 1982-83 instrumentation stocks at the same 24 medical schools and at a subsample of 43 of the 55 colleges/universities.

All statistics measuring instrumentation change from 1982-83 to 1985-86 are based on inflation-adjusted estimates of the number of research instrument systems or of the aggregate purchase price of these systems. The inflation adjustment procedure, based on U.S. Bureau of Labor Statistics annual producer price indices, is described in Appendix F.

Amounts and Prices of In-Use Research Equipment

Substantial turnover occurred in the national stock of in-use academic research equipment in the three-year period between 1982-83 and 1985-86. About one out of every four systems in research use in 1982-83 was no longer being used for research by 1985-86, and conversely, about two-fifths of all systems in research use in 1985-86 had been acquired in the three-year period since the baseline study was conducted.

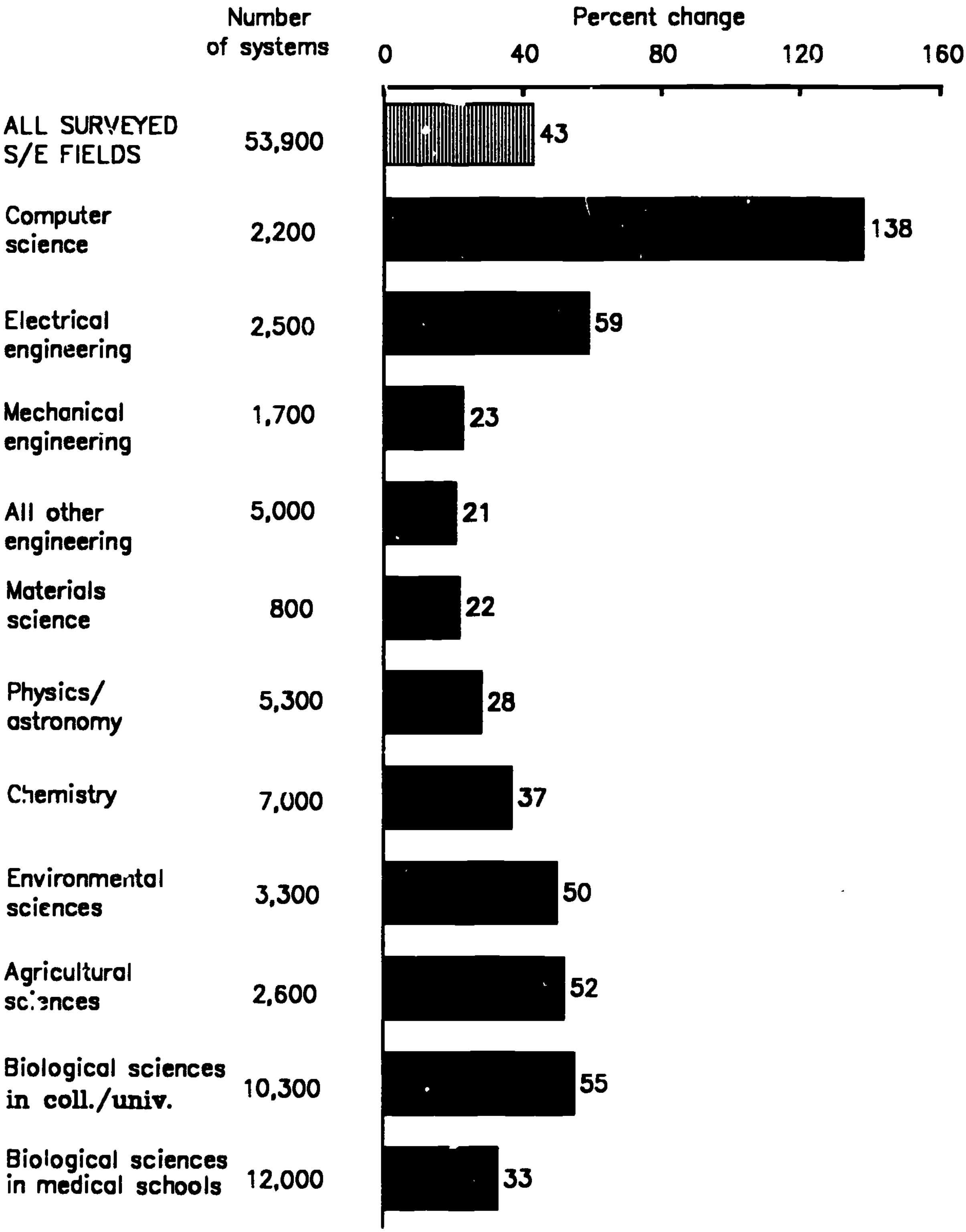
The total number of $10,000 - $1,000,000 instrument systems in S/E research use in 1985-86 was about 54,000. Adjusting for inflation in system cost ranges and other pertinent factors, this represents a 43 percent increase from 1982-83 in the national stock of in-use S/E research equipment.

All of the S/E fields surveyed experienced net increases in research equipment stocks over the 1982-83 to 1985-86 period, but rates of increase varied considerably from one field to another (Chart 1). Computer science had the most rapid rate of expansion, with its equipment stock more than doubling during this period (up 138%). The closely allied field of electrical engineering also had a comparatively high rate of instrumentation growth (up 59%). At the other extreme, comparatively low rates of growth in equipment stocks were found for mechanical engineering (up 23%), the residual of all smaller engineering disciplines (up 21%), materials science (up 22%), and physics/astronomy (up 28%). Chemistry and the environmental, agricultural, and biological sciences all experienced mid-level rates of growth, in the 37 percent to 55 percent range.

The aggregate purchase price of all S/E equipment in research use in 1985-86 was $2.0 billion, up 44 percent from 1982-83. This is essentially the same rate of net inventory growth as noted above for change in numbers of instrument systems. The mean purchase price per system for all in-use S/E research equipment in 1985-86 was $36,800, basically unchanged from 1982-83 (up only 1% after adjustment for inflation). Computer science was the only field to show a substantial real change in the mean price per unit of in-use instrumentation: there, the average price dropped from $57,800 in 1982-83 to $46,000 in 1985-86, down 22 percent after adjustment for inflation.

The top 20 R&D universities had an average of $27.9 million per institution in in-use S/E research equipment in 1985-86, much more than the average across the next 154 colleges and universities: $6.9 million. However, the <u>rate</u> of growth from 1982-83 to 1985-86 in average instrumentation stocks per institution was no greater for top 20 institutions (39%) than for those not in the top 20 (40%).

Chart 1. Number of instrument systems in research use in 1985–86 and percent change from 1982–83, by field



SOURCE: National Science Foundation, SRS

Funding Sources

In relative terms, Federal involvement in funding academic research equipment declined somewhat from 1982-83 to 1985-86. Thus, 55 percent of all systems in use in 1985-86 were acquired either partly or entirely with Federal funding support, down from 60 percent in 1982-83. Despite this relative decline, Federal funding support for in-use research equipment increased 30 percent in real dollar terms, from $663 million in 1982-83 to $906 million in 1985-86. Among the major Federal funding sources, NSF and the Department of Defense had the lowest rates of funding growth (26% and 28%, respectively), while the National Institutes of Health and the Department of Energy had larger rates of growth (46% and 36%, respectively)(Table A). Non-Federal instrumentation funding support increased by 60 percent during this same period, from $598 million of in-use equipment in 1982-83 to $978 million in 1985-86 (Appendix Tables B-13 and B-13a), a rate of increase twice as high as that for Federal sources. Within the non-Federal sector, funding from institution budgets and state government appropriations increased 57 percent, and support from business and private donations increased 69 percent.

Funding patterns differed considerably among fields, however (see Table A):

- The growth in the dollar amount of computer science instrumentation was led by a substantial influx of NSF-funded equipment (up 123%), followed by substantial increases from DOD (up 99%) and from business and private sources (up 61%).

- NSF also led the trend toward increased support for environmental science instrumentation (up 71%), with DOE and DOD also increasing their support in this field (up 70% and 44%, respectively).

- NSF, which traditionally has been a major source of funds for basic research in physics/astronomy and engineering, showed essentially no real growth in instrumentation funding in either of these broad fields. Electrical engineering achieved an above average (59%) expansion in its instrumentation inventory by obtaining large increases in equipment funding support from business and private sources (up 187%) and also from state/university funds (up 142%). Mechanical engineering also obtained substantial funding increases from non-Federal sources; state/university funds were up 66 percent, and business/private sources were up 52 percent. Physics/astronomy and the smaller fields of engineering had comparatively small funding increases from NSF and from most other sources as well.

- Chemistry had moderate instrumentation increases from NSF (up 22%) and state/university funds (up 38%), and it had above-average increases from all other major sources, both Federal and non-Federal (up 54% to 186%).

- The agricultural sciences, which receive the great bulk of their instrumentation funding support from state/university sources, had a midrange (55%) increase from those sources.

- NIH, which is the major Federal funding source for instrumentation in the biological sciences, had a net increase in this field of 44 percent, the same as the overall average across all S/E fields and sources.

Table A. Selected sources of funding for 1985-86 national stock of in-use research equipment, and percent change from 1982-83,[1] by field

Field	Total research equipment		Selected major sources of funding											
			Selected major Federal sources								State/ university funds		Business donations	
			NSF		NIH		DOD		DOE					
	1985-86	Percent change	1985-86	Percent change	1985-86	Percent change	1985-86	Percent change	1985-86	Percent change	1985-86	Percent change	1985-86	Percent change
	(dollars in millions)													
All surveyed S/E fields	$1,982	44%	$306	26%	$270	46%	$142	28%	$ 90	36%	$694	57%	$239	69%
Computer science	$ 100	85%	$ 26	123%	$ 1	**	$ 20	99%	$ <1	**	$ 25	38%	$ 20	61%
Engineering	$ 372	34%	$ 38	1%	$ 5	**	$ 59	16%	$ 17	15%	$135	35%	$ 81	87%
Electrical	$ 110	59%	$ 11	4%	$ <1	**	$ 23	11%	$ 2	**	$ 30	142%	$ 36	187%
Mechanical	$ 71	32%	$ 7	-12%	$ <1	**	$ 16	23%	$ 1	**	$ 28	66%	$ 13	52%
All other	$ 191	23%	$ 20	5%	$ 5	**	$ 20	18%	$ 14	45%	$ 78	10%	$ 32	43%
Materials science	$ 44	26%	$ 19	33%	$ <1	**	$ 3	**	$ 4	**	$ 11	23%	$ 2	**
Physics/astronomy	$ 221	16%	$ 54	1%	$ 1	**	$ 28	13%	$ 29	0%	$ 50	88%	$ 14	2%
Chemistry	$ 322	44%	$ 85	22%	$ 32	64%	$ 15	54%	$ 17	186%	$111	38%	$ 28	78%
Environmental sciences	$ 170	47%	$ 30	71%	$ <1	**	$ 10	44%	$ 15	70%	$ 56	50%	$ 27	39%
Agricultural sciences	$ 62	61%	$ 4	**	$ 2	**	$ <1	**	$ 1	**	$ 39	55%	$ 6	**
Biological sciences	$ 643	48%	$ 51	39%	$226	44%	$ 7	**	$ 4	**	$247	54%	$ 48	53%
In colleges/universities	$ 283	63%	$ 32	26%	$ 79	51%	$ 5	**	$ 2	**	$123	89%	$ 19	45%
In medical schools	$ 360	389%	$ 19	66%	$148	41%	$ 2	**	$ 2	**	$124	31%	$ 29	59%

[1] Percent change estimates are adjusted for inflation. See Appendix F.

**Unstable estimate: 1982-83 base is less than $4 million.

SOURCE: National Science Foundation, SRS

Quality of Existing Research Equipment

In addition to quantitative increases in the total size of the national stock of academic research equipment, a general qualitative upgrading in the composition of the stock also occurred during the three-year period from 1982-83 to 1985-86, with the newest and most advanced equipment becoming increasingly prominent and obsolete equipment becoming proportionately less prominent. Specifically:

- The greatest rate of growth (136%) occurred for systems and components that were still under construction/development and not yet in research use as of the end of the survey year. The dollar amount of such equipment increased from $31 million in 1982-83 to $82 million in 1985-86.

- The next highest rate of growth occurred for in-use systems that were classified by their users as state-of-the-art. These increased by 50 percent, from $371 million to $595 million.

- Other in-use systems, classified as not state-of-the-art, increased by 41 percent, from $939 million to $1.4 billion.

- Obsolete systems, ones that were inactive or inoperable throughout the year of the survey, increased by only 1 percent in real terms, from $264 million to $278 million.

This pattern of advanced equipment (i.e., still under development and state-of-the-art equipment) growing at considerably higher rates than other equipment was found at all institution types (public, private, large R&D performers, smaller institutions, medical schools, colleges/universities) and in most fields. Qualitative upgrading was most extensive in mechanical engineering (where the dollar amount of advanced equipment increased over 150% vs. a 21% increase for all other equipment in this field) and in chemistry (where advanced equipment increased 77% vs. a 26% increase for other equipment). At the other extreme, the combined smaller fields of engineering (all those other than electrical or mechanical), materials science, and the agricultural sciences all had lower rates of growth for advanced equipment than for other equipment in their fields.

Adequacy of Existing Research Equipment

Despite the pronounced quantitative increases and qualitative improvements seen from 1982-83 to 1985-86 in the research equipment stocks in most fields, little change was found in department heads' evaluations of the general adequacy of their research equipment. Across all of the S/E fields surveyed, the percentage of department heads who reported that the research equipment available to their faculty is generally "insufficient" to enable them to pursue their major research interests was essentially the same in 1985-86 (35%) as it had been in 1982-83 (36%). Chemistry was the only field where the percentage of department heads reporting insufficient equipment declined substantially over this period (Table B). On the other hand, mechanical engineering -- a field where complaints of insufficient equipment were especially common in 1982-83 (54% of departments) -- had even more widespread complaints of insufficient research equipment in 1985-86 (68% of departments).

Table B. Percent of department heads describing the research equipment available to their faculty as generally "inadequate" to enable them to pursue their major research interests, by field, 1982-83 to 1985-86

Field	Percent of department heads	
	1982-83	1985-86
All surveyed S/E fields	36	35
Computer science	45	44
Electrical engineering	58	58
Mechanical engineering	54	68
All other engineering	47	46
Materials science	14	9
Physics/astronomy	33	35
Chemistry	49	29
Environmental sciences	27	31
Agricultural sciences	46	45
Biological sciences in colleges/universities	36	32
Biological sciences in medical schools	16	24

SOURCE: National Science Foundation, SRS

Other Trends

One indication of the rapid pace of technological change in S/E research instrumentation is the finding that the median age of all 1985-86 systems classified as state-of-the-art by their principal users was only two years. In computer science, electrical engineering, chemistry and environmental science, the median for state-of-the-art equipment was even lower: one year of age.

Despite the pronounced increase in equipment stocks from 1982-83 to 1985-86, there is no indication of any slackening in equipment utilization levels. As measured by mean number of users per system per year, average utilization has actually increased slightly, from 13.9 users per system in 1982-83 to 14.2 users per system in 1985-86.

Annual expenditures for maintenance and repair (M/R) of in-use research equipment increased 41 percent from 1982-83 to 1985-86 in real terms, generally keeping pace with the level of expansion of equipment inventories over this period (44%). Service contracts became an increasingly dominant component of M/R costs, however, with annual expenditures for service contract increasing at a much greater rate (67%) than expenditures for field service (13%) or in-house M/R (12%).

The percentage of in-use systems judged by their principal users to be in "excellent" working condition increased slightly, from 52 percent in 1982-83 to 55 percent in 1985-86.

Conclusions

The findings described in this report do not translate readily into conclusions about whether or not the quantitative and qualitative changes that have occurred from 1982-83 to 1985-86 in academic research equipment are sufficient to maintain the "competitiveness" of American science and technology. No doubt, experts in particular areas of research will find much in the report's detailed statistical tables that will raise questions about whether current levels of instrumentation support are adequate to meet the need and about whether that support is being directed to the right fields and institutions.

Nevertheless, while there remains considerable room for debate about the adequacy of the changes that have occurred from 1982-83 to 1985-86, the findings reported here seem quite clear as to the direction of change. Instrumentation stocks have been substantially replenished and enhanced during this period, in all of the science/engineering fields surveyed in this study and in all major institution categories -- public, private, large, small.

The net growth and qualitative improvement in instrumentation stocks have resulted from substantially increased levels of instrumentation funding support from all sources. Measured in terms of accumulated funding contributions to the total stock of in-use research equipment, the relative increase in Federal instrumentation support from 1982-83 to 1985-86 was smaller than the increases seen from other sources. The colleges and universities themselves, business and private donors, and state governments financed most of the growth in research instrumentation.

In relative terms, computer science was the greatest beneficiary of the overall increase in instrumentation support, particularly from Federal sources. However, computer science was a very small field in 1982-83, so a comparatively modest increase in support dollars could (and did) produce a comparatively large impact.

At the other extreme, engineering had the most equivocal results of the fields studied in this analysis. Total instrumentation stocks and investments increased, but unevenly. Non-Federal sources provided most of the funding increase. While there were demonstrable equipment stock increases, engineering also registered rising rates of equipment usage, and maintenance costs have ballooned. Department heads' qualitative assessments indicated no perceived improvement in the overall adequacy of available research equipment or in the adequacy of instrumentation support resources. Engineering may be a field that has been running hard just to stay even and that soon may have increasing difficulties in maintaining current stocks of basic research equipment.

INTRODUCTION

BACKGROUND

In 1980, an Association of American Universities (AAU) survey of investigators at 16 leading research universities identified what seemed to be an emerging instrumentation crisis in academic science and engineering.[1] The AAU study reported numerous instances where scientists and engineers felt that, because of inadequate instrumentation, they were no longer able -- or were on the verge of being no longer able -- to work at the frontiers of research in their respective fields. At that time, however, the evidence was almost entirely anecdotal.

In recognition of the need for "objective information in the area," the House Committee on Science and Technology recommended that the National Science Foundation "conduct inventories of, and analyses of the needs for, scientific instrumentation."[2] The resulting legislation, when enacted and signed into law, directed the Foundation to "develop indices, correlates or other suitable measures or indicators of the status of scientific instrumentation in the United States and of the current and projected need for scientific and technological instrumentation."[3]

In response to this mandate, the Foundation initiated a feasibility study to design quantitative indicators of current status and trends in academic research instrumentation and to determine the most appropriate methods of data collection.[4] Final specifications for a baseline national survey were determined by NSF following extensive review of the feasibility study findings by other Federal agencies and by several advisory groups of university scientists and research administrators.

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[1] Association of American Universities. The Scientific Instrumentation Needs of Research Universities, Report to NSF, 1980.

[2] House of Representatives Report No. 96-61 (1979), p. 30.

[3] An Act To Authorize Appropriations for Activities for the National Science Foundation for Fiscal Year 1980, and for Other Purposes. Public Law 96-44, Section 7.

[4] Indicators of Scientific Research Instrumentation in Academic Institutions: A Feasibility Study. Westat, Inc., March 1982.

THE BASELINE SURVEY

The 1982-83 baseline survey, as it has come to be known, was designed to produce quantitative indicators of the national stock, cost/investment, condition, obsolescence, utilization, and need for major research instruments in academic settings. The baseline survey was conducted in two stages, or phases. Phase I, conducted during 1983 at a stratified probability sample of 43 universities (excluding Federally-funded R&D Centers), obtained information about existing instruments and instrumentation needs in the physical and computer sciences and engineering as of the end of calendar 1982. Phase II, conducted during 1984, completed the baseline cycle by collecting data for the agricultural, biological, and environmental sciences regarding instrumentation stocks in place at the end of calendar 1983. The same universities that participated in Phase I contributed to Phase II as well, together with a separately drawn sample of 24 medical schools, needed to provide a comprehensive picture of academic instrumentation in the biological sciences.[5]

In each phase, two kinds of baseline data were collected. First, all departments and nondepartmental research facilities in applicable fields were asked to provide information about selected characteristics of the department or facility as a whole, particularly regarding research equipment costs and needs. Second, from equipment listings supplied by the university, a sample of research instrument systems was selected from each department and facility, and the principal investigator (or other knowledgeable individual) was asked to provide information about the instrument's cost, age, condition, usage, etc. These latter data were used to construct quantitative statistical indicators of the cost, condition, etc. of the national stock of existing academic research instruments in the fields surveyed.

The equipment survey component of the baseline study was restricted to instrument systems with an original purchase cost of $10,000 to $1 million. Systems above this range are generally subject to specific, case-by-case needs assessment at time of acquisition, and their continued operation is individually subject to ongoing policy analysis. At the other extreme, it was the consensus of NSF advisors that individual pieces of equipment below $10,000 are seldom of

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[5]Funding support for the medical school component of the Phase II data collection was provided by the National Institutes of Health in both the baseline and update surveys.

critical importance in determining whether an academic scientist or engineer is able to pursue his or her research interests.

THE UPDATE SURVEY

The 1985-86 National Study was intended to update the national estimates that were obtained three years earlier in the baseline study and to document instrumentation-related changes during the period between the two studies. With three exceptions, the methodology of the update survey was essentially the same as in the baseline:

1. The college/university universe to which the 1985-86 study estimates apply was updated to encompass the 174 institutions with FY 1984 separately-budgeted R&D expenditures of $3 million or more (excluding medical schools). Using the same criterion with FY 1980 R&D expenditures data, the baseline study universe consisted of 154 institutions.

2. The college/university sample was expanded from 43 to 55 institutions. The update study sample includes all baseline study institutions, plus 12 others. The current sample includes all colleges/universities that are in the top 20 in FY 1984 R&D expenditures in science and engineering, plus a sample of 35 of the remaining 154 institutions in the study universe.

3. To reduce response burden for participating institutions, engineering departments and departments within the agricultural and biological sciences were subsampled in the update study. In the baseline, all departments in applicable fields were asked to participate.

The above changes apply only to the college/university component of the survey. For the medical school component, no changes were made in the institution universe or sample, and there was no subsampling of biological science departments within medical schools.

As was true for the baseline study, the response rates in the 1985-86 update survey were very high:

- One hundred percent of the 79 sampled institutions agreed to participate in the update survey. The baseline study also enjoyed 100 percent participation at the institution level.

- Ninety-two percent of the 1,050 sampled departments and facilities responded to the department/facility questionnaire, down slightly from 94 percent in the baseline study.

- Responses were received for 94 percent of the 14,424 sampled instruments within sampled departments and facilities, down slightly from the 96 percent instrument-level response rate in the baseline study.

Whatever else the content of the responses may reveal, these high levels of response in both the baseline and update surveys indicate a strong and unabated interest throughout the academic community in the central topic of this survey -- the adequacy of existing research equipment.

THIS REPORT

This analysis of data from the 1985-86 NSF instrumentation survey has two principal objectives: (a) to develop quantitative statistical indicators of the current national stock of academic research equipment in the major science/engineering fields, and (b) to document changes in these indicators since the previous (1982-83) study. Throughout this report, the emphasis is upon the identification and description of major changes from 1982-83 to 1985-86 in the quantity, quality, cost, and condition of academic research equipment in the United States, with minimal speculation either about the root causes or about the public policy implications of these changes. The analysis is divided into four major sections:

1. Overall trends and trends by type of institution;
2. Trends in the physical and environmental sciences;
3. Trends in engineering, computer science, and materials science; and
4. Trends in the agricultural and biological sciences.

In each section, findings are highlighted regarding trends from 1982-83 to 1985-86 in equipment amounts, funding sources, quality/adequacy, usage patterns, and maintenance/repair.

Further information about the survey design, response rates, and analysis procedures -- including definitions of key analysis variables -- is presented in Appendix A

(Technical Notes). The detailed statistical tables, which provide the basis for the following discussion, are presented in Appendix B. These appendix tables contain a wider range of statistics and a larger number of field breakouts (representing multiple levels of aggregation/ disaggregation) than are discussed in the text. Additional information about the survey is provided in Appendices C-G.

The discussion of trend findings contains numerous references to changes from 1982-83 to 1985-86 in equipment-related expenditures, dollar amounts, numbers of instrument systems, etc. All such direct measures of change adjust for the effects of inflation by comparing estimates from the 1982-83 study to inflation-adjusted versions of the same estimates, as calculated from the 1985-86 data. The inflation adjustment procedure, which is based on annual producer price indices published by the U.S. Bureau of Labor Statistics, is described in Appendix F. The inflation-adjusted versions of such 1985-86 estimates are presented in the detailed statistical tables in Appendix B, along with the analogous estimates for 1982-83 and with the unadjusted estimates for 1985-86. In the presentation and discussion of findings from the 1985-86 survey, however, it is always the unadjusted estimates that are cited in the text and in text tables.

RESULTS

1. OVERALL TRENDS AND TRENDS BY TYPE OF INSTITUTION

1.1 QUANTITY OF ACADEMIC RESEARCH EQUIPMENT

This section examines trends from 1982-83 to 1985-86 in the amount of academic research equipment, overall and by type of college/university (public vs. private, top 20 in R&D expenditures vs. not in top 20).[1] Part A describes quantitative trends in amounts of in-use research equipment in the $10,000 to $1 million range, the equipment category of primary interest in this research. Limited information is also available about trends for more broadly defined groupings of equipment, including equipment that is physically present but not in active research use (e.g., obsolete equipment and equipment still under construction/development) and research systems costing over $1 million per unit. Part B presents trend findings for these latter categories of equipment. Here and throughout this report, equipment amount is measured in terms of both the number of research instrument systems and the aggregate purchase price of these systems. All measures of change in equipment amounts are adjusted for inflation (see Appendix F).

A. Change in Amounts of In-use Research Equipment

Substantial turnover occurred in the national stock of in-use academic research equipment in the three-year period between 1982-83 and 1985-86. About one out of every four systems in research use in 1982-83 was no longer being used for research by 1985-86, and conversely, about two-fifths of all systems in research use in 1985-86 had been acquired in the three-year period since the Cycle I study was conducted (Table 1). These rates were no different for private than for public colleges and universities, and they were no different at the top 20 R&D institutions than at the smaller R&D performers.

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[1]Data from biological science departments in medical schools are included in the overall findings but not in the institution type categories used in this section. Findings for medical school biological science departments are discussed in Section 4.

Table 1. Equipment retirement and acquisition rates by type of institution, 1982-83 to 1985-86[1]

Index	Total	Colleges/universities			
		Private	Public	Top 20 in R&D	Not in top 20
Retirements			(percent)		
Of systems in research use in 1982-83, percent retired in the 3-year period 1982-83 to 1985-86	23%	23%	24%	24%	24%
Acquisitions					
Of systems in research use in 1985-86, percent acquired in the 3-year period 1982-83 to 1985-86	37%	39%	38%	40%	37%

[1]From Appendix Table B-6. Medical schools, which are discussed elsewhere, are included in the total but not in the college/university subtypes.

SOURCE: National Science Foundation, SRS

The total dollar amount of in-use research equipment in the $10,000 to $1 million range was $2.0 billion in 1985-86. Adjusting for inflation, this represents a net increase of 44 percent from the analogous figure for 1982-83, $1.3 billion (Table 2). Changes of similar magnitude occurred for two other measures of total quantity of in-use research equipment -- the total number of in-use systems increased 43 percent, and the average (mean) dollar amount of in-use research equipment per institution was up 39 percent. These quantitative estimates were all derived from the survey of instruments sampled from institution property inventory records. Another quantitative indicator, derived from the survey of department heads, is the average (mean) annual expenditure per institution for purchase of research equipment. This department-based measure of annual equipment expenditures increased 44 percent from 1982-83 to 1985-86, consistent with the instrument-level trend data (Table 2).

Table 2. Instrumentation amounts, prices, and expenditures, by type of institution, 1982-83 to 1985-86[1]

Index	Total	Colleges/universities			
		Private	Public	Top 20 in R&D	Not in top 20
Number of systems in research use					
1982-83	36,300	8,900	18,500	10,000	17,400
1985-86	53,900	11,900	29,800	14,600	27,200
Percent change[2]	43%	29%	54%	42%	44%
Aggregate purchase price of systems in research use (dollars in millions)					
1982-83	$1,311	$370	$684	$389	$664
1985-86	$1,982	$494	$1,120	$558	$1,055
Percent change[2]	44%	27%	54%	39%	48%
Mean amount of in-use equipment per institution (dollars in millions)					
1982-83	$5.31	$7.23	$6.58	$19.46	$4.92
1985-86	$7.45	$8.82	$9.49	$27.91	$6.85
Percent change[2]	39%	27%	43%	39%	40%
Mean price per system					
1982-83	$36,100	$41,600	$37,000	$39,100	$38,200
1985-86	$36,800	$41,300	$37,500	$38,200	$38,800
Percent change[2]	1%	-2%	0%	-4%	1%
Mean annual expenditures per institution for research equipment (dollars in millions)					
1982-83	$1.67	$2.30	$2.06	$5.[illegible]4	$1.60
1985-86	$2.58	$3.49	$3.33	$10.04	$2.52
Percent change[2]	44%	47%	[illegible]0%	[illegible]7%	48%

[1]From Appendix Tables B-7 to B-10, B-34 to B-35. Medical schools, which are discussed elsewhere, are included in the total but not in the college/university subtypes.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

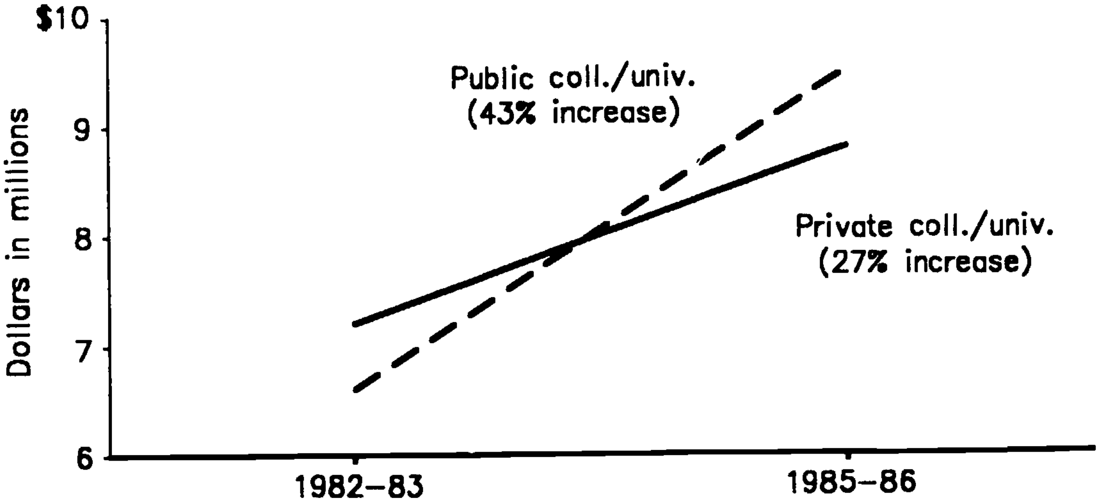
SOURCE: National Science Foundation, SRS

One quantitative measure that did not change much was the average (mean) purchase price per in-use research system. In 1985-86, the average price per system was $36,800, essentially unchanged (after adjustment for inflation) from the 1982-83 average of $36,100 per system (Table 2). This finding does not imply that prices have remained stable for most kinds of equipment over the three year-period encompassed by this analysis. On the contrary, examination of unit cost data for specific categories of research equipment in the biological sciences (electron microscopes, diffractometers, ultracentrifuges, etc.) suggests that different kinds of equipment have experienced widely varying changes over this period, in unit price and/or in frequency of purchase. Apparently, however, the various changes have evened out in the aggregate, leaving the statistical average price per system in 1985-86 much the same as it was in 1982-83.

The top 20 R&D universities had an average of $27.9 million per institution in in-use research equipment in 1985-86, much more than the average across the next 154 colleges and universities: $6.9 million. However, the rate of growth from 1982-83 to 1985-86 in per institution average instrumentation amounts was essentially the same for top 20 institutions (39%) as for those not in the top 20 (40%) (Table 2).

In 1982-83, the average amount of in-use research equipment per institution was slightly higher for private colleges and universities ($7.2 million per institution) than for ones in the public sector ($6.6 million). However, the rate of growth in average instrumentation stocks over the next three years was considerably lower for private than for public colleges/universities (27% and 43%, respectively), with the result that the average 1985-86 equipment level for private colleges/universities had become lower than the corresponding average for public institutions ($8.8 million and $9.5 million, respectively) (Figure 1). Other measures of trends in accumulated amounts of in-use research equipment also showed substantially higher growth rates at public than at private institutions (Table 2).

Figure 1
Mean dollar amount of in-use instrumentation[1] per institution, by control of institution, 1982-83 to 1985-86[1]



[1] The data do not include medical schools. The straight lines connecting the two data points are not meant to imply linear increases throughout the intervening period.

SOURCE: National Science Foundation, SRS

B. Trends for the Total Stock of All Research Equipment Valued at $10,000 or More

The total national stock of academic research equipment costing $10,000 or more per system -- including obsolete equipment and equipment costing over $1 million -- increased from $2.3 billion to $3.4 billion over the three-year period from 1982-83 to 1985-86 (Table 3). This represents an increase of 44 percent over this period, about the same as noted earlier for the subset of in-use equipment in the $10,000 to $1 million range. The totality of all equipment in the $10,000 to $1 million cost range increased from $1.6 billion to $2.3 billion (38%). Large systems that were beyond the scope of the study's detailed data collection, generally because they cost more than $1 million per unit, increased at an even greater rate, 56 percent (from $700 million to $1.1 billion).

Among large systems, 75 percent of the 1985-86 dollar value was in computer centers (either general purpose computers or computers dedicated for research applications). The dollar amount of equipment in academic computer centers used partly for research nearly doubled (up

Table 3. Aggregate purchase price of academic reseach equipment, including systems costing more than $1 million, by equipment category and type of college/university: National estimates, 1982-83 to 1985-86[1]

Equipment category and college/ university type	Aggregate purchase price (dollars in millions)		
	1982-83	1985-86	Percent change[3]
Total[2]	$2,303	$3,441	44%
Equipment category			
Systems costing $10,000 - $1 million	1,605	2,342	38
Large systems (generally over $1 million), total	698	1,099	56
General purpose research computer centers	420	799	88
Dedicated research computers	3	29	861
Research vessels	17	27	56
High energy physics systems	164	165	0
Observatories	38	13	-65
Other large systems	55	66	14
College/University type			
Private	694	913	26
Public	1,319	2,116	54
Top 20 in R&D	749	960	25
Not in top 20	1,264	2,068	56

[1]From Appendix Table B-1.

[2]Medical schools, which are discussed elsewhere, are included in the total but not in the college/university subtypes.

[3]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

30

88%), from $420 million in 1982-83 to $799 million in 1985-86. Equipment in academic computer centers dedicated entirely to research increased by over 800 percent,[2] from $3 million in 1982-83 to $29 million in 1985-86. Markedly different trends were found for large systems in physics/astronomy, however: there was no net growth in large systems for research in high energy physics ($165 million in both 1982-83 and 1985-86, in constant-dollar terms), and equipment in observatories actually declined by 65 percent (Table 3).

Comparing public and private colleges/universities, the trends for all research equipment costing $10,000 or more are similar to the trends noted earlier for the subset of equipment that was in active research use and cost $10,000 to $1 million: public colleges/universities had a substantially larger rate of growth than did private institutions: 54 percent vs. 26 percent (Table 3).

Colleges/universities not in the top 20 in total R&D expenditures had a substantially larger rate of growth in dollar amount of all $10,000 or more equipment than did the "top 20" colleges/universities: 56 percent vs. 25 percent (Table 3). This difference between the largest and the smaller R&D performers is much greater than that seen earlier for the subset of in-use research equipment in the $10,000 to $1 million range. It appears to indicate that, in the three-year period from 1982-83 to 1985-86, there has been an especially pronounced expansion of central computing facilities at intermediate-size colleges/universities, those that are not in the top 20 but that have more than $3 million in annual R&D expenditures.

In the period 1982-83 to 1985-86, some notable shifts have occurred in the distribution of research equipment among the fields represented in this study. All fields evidenced increases in the total dollar amount of research equipment in the $10,000 to $1 million range (including both in-use and not-in-use equipment), but some fields increased (or decreased) their share of the total (Table 4). Thus, physics/astronomy evidenced the largest relative decline in research equipment, from 14.0 percent of the 1982-83 total to 12.1 percent of the 1985-86 total (-1.9 percentage points). The largest relative increase (also of 1.9 percentage points) occurred in biological science

[2]These findings refer to observatories, reactors, accelerators, and other large research systems in academic settings, with the exception of 18 facilities formally designated as university-administered FFRDC's (Federally-funded Research and Development Centers).

departments in colleges/universiti^s, which grew from 11.5 to 13.4 percent from 1982-83 to 1985-86. Computer science, electrical engineering, and mechanical engineering also experienced noteworthy relative increases in equipment shares, while the smaller ("other") engineering fields collectively declined (Table 4).

Table 4. Change from 1982-83 to 1985-86 in the distribution of academic research equipment, by field[1]

Field	1982-83		1985-86		Change in percent
	Total stock[2]	Percent of stock	Total stock[2]	Percent of stock	
	(dollars in millions)				
All surveyed S/E fields	$1,604.9	100.0%	$2,342.2	100.0%	0
Computer science	59.4	3.7	105.7	4.5	0.8
Electrical engineering	79.9	5.0	126.4	5.4	0.4
Mechanical engineering	67.2	4.2	105.0	4.5	0.3
Other engineering	181.4	11.3	229.6	9.8	-1.5
Materials science	37.1	2.3	48.2	2.1	-0.2
Physics/astronomy	225.2	14.0	282.7	12.1	-1.9
Chemistry	251.8	15.7	365.4	15.6	-0.1
Environmental sciences	124.7	7.8	199.7	8.5	0.7
Biological sciences in medical schools	284.6	17.7	402.0	17.2	-0.5
Biological sciences in colleges/universities	184.8	11.5	313.0	13.4	1.9
Agricultural sciences	42.4	2.6	67.4	2.9	0.3
Other, n.e.c.	66.4	4.1	97.0	4.1	0.0

[1]From Appendix Tables B-4 and B-4a.

[2]All physically present research equipment in $10,000-$1 million range, including systems that are inactive/inoperable, systems in research use, and systems not yet in research use

SOURCE: National Science Foundation, SRS

32

1.2 SOURCES OF FUNDS FOR IN-USE EQUIPMENT

In relative terms, Federal funding support for academic research equipment declined somewhat from 1982-83 to 1985-86. Thus, 55 percent of all in-use systems in 1985-86 were acquired, either partially or entirely, with Federal funding support, down from 60 percent in 1982-83. This trend exists in all types of institutions (Appendix Table B-12).

Although its share declined, Federal funding support for in-use research equipment increased 30 percent in real dollar terms, from $663 million in 1982-83 to $906 million in 1985-86 (Table 5). Among the major Federal funding sources, NSF and the Department of Defense had the lowest rates of funding growth (26% and 28%, respectively), while the Department of Energy and the National Institutes of Health had larger rates of growth (36% and 46%, respectively).

Non-Federal sources of instrumentation funding support generally increased at rates considerably higher than those seen for Federal sources: funding from institution budgets increased 47 percent, State government support increased 72 percent, support from business and private donations increased 69 percent, and support from other sources (mainly foundations) increased 61 percent (Table 5).

Private colleges and universities have been more dependent upon Federal instrumentation support than have public institutions. In 1982-83, private institutions had an average of $4.31 million per institution in Federally funded equipment (representing 62% of the value of their in-use research equipment), as compared to $3.08 million per institution at public colleges and universities (which represented only 48 percent of the total value of <u>their</u> in-use research equipment) (see Appendix Table B-13a). In 1985-86, private colleges/universities still had comparatively large amounts of Federally funded research equipment -- $4.9 million per private institution vs. $3.8 million per public institution -- although the percentage growth in Federal instrumentation support was not as great for private as for public institutions (19% and 34%, respectively) (Figure 2). This comparatively low rate of increase from private institutions' major source of instrumentation support (the Federal government), together with the fact that the large growth in State-sponsored instrumentation support impacted almost entirely on public institutions (Table 5), largely accounts for the comparatively small overall increase in instrumentation stocks at private institutions that was noted earlier.

Table 5. Sources of funds for purchase of systems in use in 1985-86 and percent change from 1982-83 by type of institution[1]

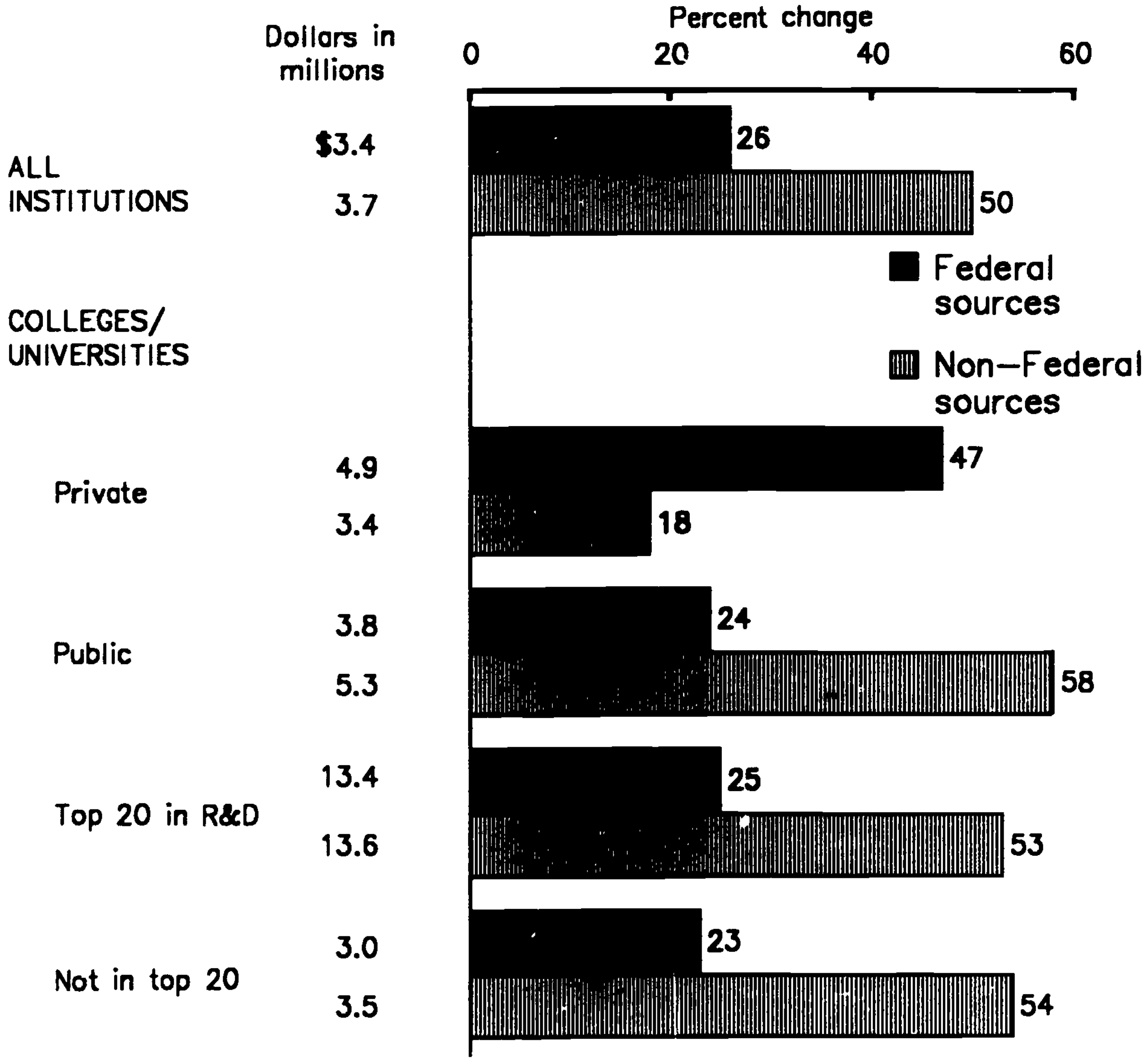
Source of funds	Total		Colleges/universities: Private		Colleges/universities: Public		Colleges/universities: Top 20 in R&D		Colleges/universities: Not in top 20	
	1985-86	Percent change[2]	1985-86	Percent change[2]	1985-86	Percent change[2]	1985-86	Percent change[2]	1985-86	Percent change[2]
	(dollars in millions)									
Total, all reported sources	$1,884	42%	$466	24%	$1,077	53%	$540	38%	$1,003	46%
All Federal sources	$906	30%	$277	19%	$453	34%	$268	25%	$462	30%
NSF	$306	26%	$118	14%	$170	32%	$116	28%	$172	21%
NIH	$270	46%	$49	50%	$71	56%	$44	42%	$76	62%
DOD	$142	28%	$64	16%	$76	41%	$53	29%	$86	27%
DOE	$90	36%	$17	24%	$72	43%	$28	25%	$60	47%
All others	$99	9%	$30	9%	$66	8%	$27	7%	$68	17%
All non-Federal sources	$978	55%	$190	32%	$624	49%	$273	58%	$540	63%
Institution funds	$580	47%	$99	28%	$367	61%	$160	36%	$306	64%
State government	$114	72%	$2	-	$98	66%	$26	88%	$73	58%
Business/private donations	$239	69%	$79	36%	$130	101%	$77	97%	$133	57%
Other	$45	61%	$10	52%	$28	97%	$10	26%	$29	118%

[1]From Appendix Tables B-13 to B-14a. Medical schools, which are discussed elsewhere, are included in the total but not in the college/university subtypes.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Figure 2
Mean dollar amount of in-use research equipment per institution in 1985-86, by type of institution and source of funds, and percent change from 1982-83[1]



[1]Medical schools, which are discussed elsewhere, are included in total but not in the college/university subtypes.

SOURCE: National Science Foundation, SRS

1.3 QUALITY/ADEQUACY OF EXISTING EQUIPMENT

It appears that there has been an increase in the overall quality, as well as in the quantity, of the national stock of academic research equipment from 1982-83 to 1985-86. Several indicators point to this conclusion.

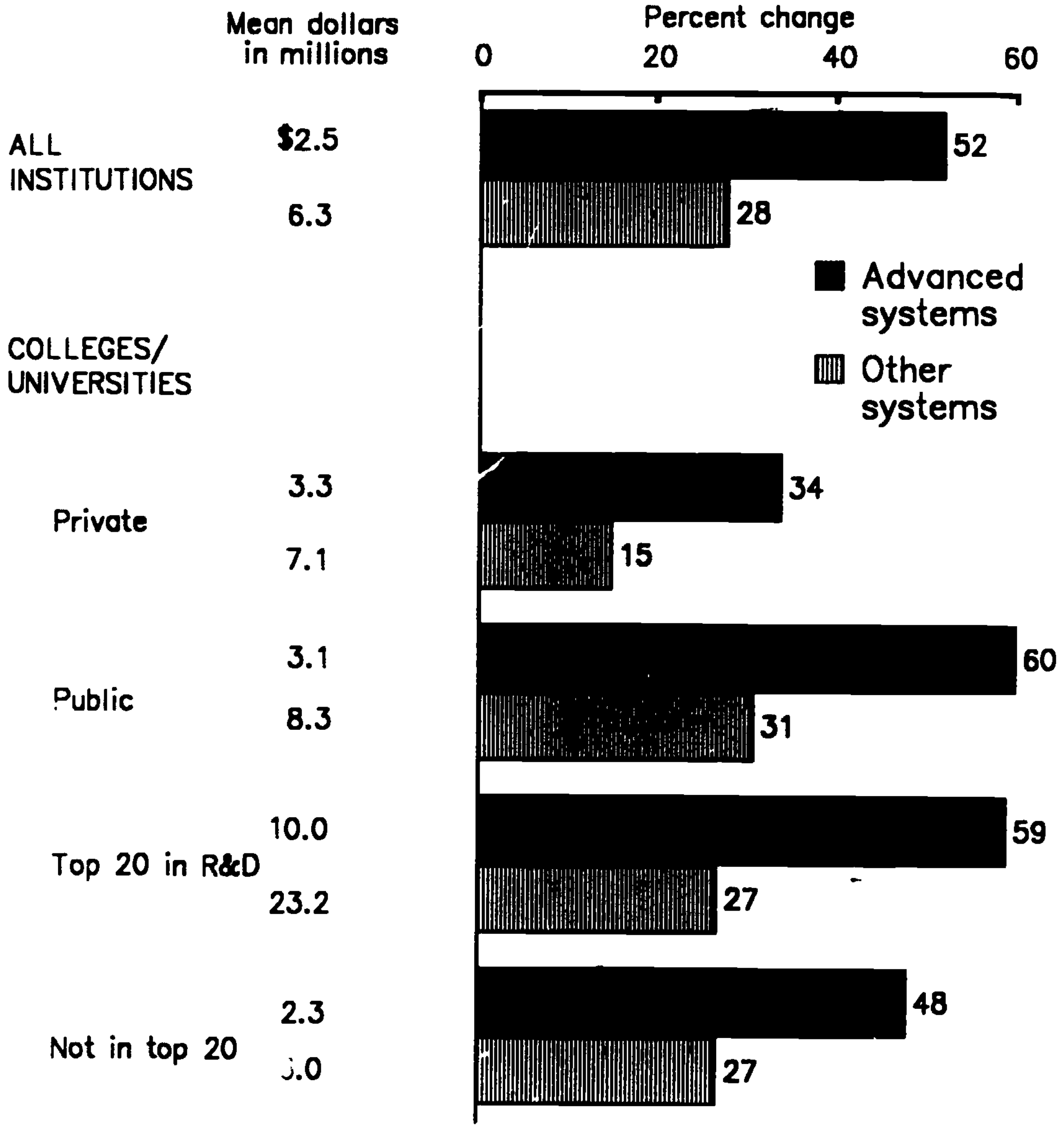
Obsolescence

Perhaps the clearest indication of improved quality in the national stock of academic research equipment is that the greatest rates of net growth from 1982-83 to 1985-86 occurred among the most advanced (least obsolete) categories of equipment. Thus, breaking down the overall 38 percent increase in the total stock of equipment in the $10,000 to $1 million range (Table 6):

- Systems and components that were still under construction/development and not yet in research use as of the end of the survey year increased 136 percent, from $31 million in 1982-83 to $82 million in 1985-86;
- In-use systems classified by their users as state-of-the-art increased by 50 percent, from $371 million to $595 million;
- Other in-use systems, classified as not state-of-the-art, increased by 41 percent, from $939 million to $1.4 billion; and
- Obsolete systems, ones that were inactive or inoperable throughout the year of the survey, increased by only 1 percent in real terms, from $263 million to $278 million.

This pattern of much greater increases in advanced than in obsolete equipment is found in both the large (top 20) R&D performers and the smaller institutions (Figure 3). The pattern is highly characteristic of public institutions, where the rates of real growth in not-yet-in-use equipment (223%) and in state-of-the-art equipment (60%) were especially high (Table 6). Private institutions, which experienced a comparatively low overall rate of growth in instrumentation stocks, also evidenced comparatively little qualitative differentiation (the rates of growth being 20% for not-yet-in-use, 36% for state-of-the-art, 22% for other in-use, and 11% for obsolete equipment) (Table 6).

Figure 3
Mean dollar amount of research equipment per institution in 1985–86 and percent change from 1982–83, by system status[1] and type of institution[2]



[1] Advanced systems include ones that are still under development and not yet in use, plus in-use systems that are judged by their users to be state-of-the-art. Other systems include in-use systems that are not state-of-the-art, plus inactive/inoperable systems.

[2] Medical schools, which are discussed elsewhere, are included in total but not in the college/university subtypes.

SOURCE: National Science Foundation, SRS

Table 6. Aggregate dollar amount of academic research equipment, by system status, 1982-83 to 1985-86[1]

System status	1982-83	1985-86	Percent change[2]
	(in millions of dollars)		
All systems $10,000 to $1 million	$1,605	$2,342	38%
Advanced systems	$502	$677	56%
Not yet in use	$31	$82	136%
State-of-the-art	$371	$595	50%
Other systems	$1,202	$1,665	32%
Other in-use	$939	$1,387	41%
Inactive/inoperable	$263	$278	1%

[1]Derived from Appendix Tables B-4 and B-4a.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Access to Advanced Instrumentation

We tend to think of non-state-of-the-art research equipment as being outdated, limiting, and generally undesirable. This is an oversimplification, however. In fact, it can be highly advantageous for a department to have substantial amounts of non-state-of-the-art equipment on hand, as long the research users of such equipment have access to more advanced instrumentation when needed. Thus, one indication of improving quality/adequacy of an institution's stock of research equipment would be an increase in the proportion of non-state-of-the-art systems whose users have access to more advanced equipment when needed. Such an increase was found, overall (from 54% to 62% between 1982-83 and 1985-86) and for all major institution types (increases of similar magnitude) (Table 7).

38

Table 7. Adequacy of existing research equipment, by type of institution, 1982-83 to 1985-86[1]

Index	Total		Colleges/universities: Private		Public		Top 20 in R&D		Not in top 20	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Percent of non-state-of-the-art systems whose users also have access to more advanced systems when needed	54%	62%	52%	62%	52%	61%	56%	63%	50%	60%
Percent of department heads assessing the overall adequacy of the research equipment available to their faculty as:										
Excellent	11%	11%	13%	18%	8%	9%	4%	12%	11%	11%
Adequate	54%	54%	55%	57%	48%	49%	55%	57%	48%	39%
Insufficient	36%	35%	31%	25%	45%	42%	40%	31%	41%	41%

[1]From Appendix Tables B-20 and B-31. Medical schools, which are discussed elsewhere, are included in the total but not in the college/university subtypes.

SOURCE: National Science Foundation, SRS

Department Heads' Perceptions

There was no overall change from 1982-83 to 1985-86 in the percent of science/engineering (S/E) department heads who characterized as insufficient the research equipment available to their faculty. However, among S/E department heads at top 20 institutions in R&D, a slight decline was found in the percent characterizing their equipment as insufficient: down from 40 percent in 1982-83 to 31 percent in 1985-86 (Table 7).

1.4 USAGE PATTERNS

Despite the pronounced quantitative and qualitative changes that occurred from 1982-83 to 1985-86 in the national stock of in-use research equipment, little change was found in the places, ways, or frequencies with which research equipment is used (Table 8). Thus, little change was found in the proportions of systems assigned to different kinds of research laboratories (within-department labs of individual investigators, department-managed common labs, etc.) or in the proportion of systems dedicated for use in a specific experiment or series of experiments. The average (mean) number of research users per system per year also remained essentially unchanged, overall and for different kinds of equipment.

This last finding, that the average number of users per system has not declined despite the substantial increase in the total numbers of systems in research use, is consistent with department heads' assessments that the general adequacy of available research instrumentation -- in terms of its ability to permit faculty to pursue their major research interests -- did not change greatly from 1982-83 to 1985-86. Taken together, these findings suggest that the quantitative and qualitative increases in instrumentation that have occurred during this three-year period, while substantial, have not been large enough to produce any demonstrable surfeit of equipment.

1.5 MAINTENANCE AND REPAIR

Annual expenditures for maintenance and repair (M/R) of in-use research equipment grew substantially during the period 1982-83 to 1985-86, from $50 million to $79 million (Table 9). This increase of 41 percent is of about the same magnitude as the 44 percent growth over this period in the total dollar amount of in-use equipment (Table 2). Consequently, when annual M/R expenditures are expressed as a percent of the dollar value of the equipment to be maintained, annual M/R expenditures have remained roughly constant at about 4-percent of aggregate equipment purchase price (Table 9).

Table 8. Patterns of equipment usage, by type of institution, 1982-83 to 1985-86[1]

Index	Total		Colleges/universities							
			Private		Public		Top 20 in R&D		Not in top 20	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Percent of in-use systems located in:										
Within-department labs of individual principal investigators (PI's)	59%	56%	60%	65%	56%	51%	58%	54%	57%	56%
Department-managed common labs	32%	31%	27%	25%	34%	33%	29%	32%	33%	30%
Other shared-access locations	8%	13%	13%	10%	10%	16%	13%	14%	10%	[illegible]%
Percent of in-use systems that are:										
Dedicated for use in a specific experiment or series of experiments	27%	31%	33%	36%	29%	32%	31%	31%	29%	34%
Available for general purpose use	73%	69%	67%	64%	71%	68%	69%	69%	71%	66%
Mean number of users per system per year										
All in-use sytems	14	14	18	16	14	15	19	17	13	14
Dedicated	8	8	9	8	8	8	10	10	7	8
General purpose	16	17	22	20	16	18	22	20	15	17

[1]From Appendix Tables B-21, B-24, and B-26 Medical schools, which are discussed elsewhere, are included in the total but not in the college/university subtypes.

SOURCE: National Science Foundation, SRS

Table 9. Maintenance and repair (M/R) of research equipment, by type of institution, 1982-83 to 1985-86[1]

Index	Total		Colleges/universities							
			Private		Public		Top 20 in R&D		Not in top 20	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985 86	1982-83	1985 86	1982-83	1985-86
Annual expenditures for M/R										
Total (dollars in millions)	$50.0	$79.0	$14.9	$21.4	$24 8	$44.5	$15.5	$22.1	$24.3	$43.7
Percent change from 1982-83[2]		41%		27%		58%		30%		56%
M/R expenditures as a percent of system purchase price	3 8%	4.0%	4 1%	4.3%	3.6%	3.9%	4.0%	4.0%	3.7	4.1
Annual expenditures for service contracts										
Total (dollars in millions)	$25.7	$48.3	$8.0	$13.3	$9.8	$24.5	$7.1	$12.9	$10.7	$24.9
Percent change from 1982-83[2]		67%		47%		120%		65%		102%
Annual expenditures for all other forms of M/R										
Total (dollars in millions)	$24 3	$30.7	$6.9	$8.1	$15.0	$20.0	$8.4	$9.3	$13.6	$18.7
Percent change from 1982-83[2]		12%		4%		17%		1%		20%
Percent of in-use systems with M/R from:										
Service contracts	24%	24%	22%	26%	17%	19%	18%	20%	19%	21%
Other means of service	58%	50%	58%	47%	65%	55%	64%	53%	63%	53%
No M/R was required	18%	26%	19%	28%	17%	26%	19%	28%	17%	26%
Mean annual M/R expenditures per system (dollars in thousands)										
Service contracts	$3.2	$3.9	$4.4	$4.5	$3.3	$4.6	$4.4	$4.6	$3.4	$4.6
All other means of M/R	$2.5	$2.5	$2.8	$3.3	$2.8	$2.7	$2.9	$2.7	$2.7	$2.9
General working condition of in-use systems (percent of systems)										
Excellent	52%	55%	54%	52%	51%	56%	51%	55%	52%	55%
Adequate	38%	38%	35%	41%	39%	37%	38%	38%	38%	39%
Poor	10%	7%	10%	7%	10%	7%	11%	7%	10%	7%

[1]From Appendix Tables B-8, B-17, B-27, B-28, B-28a, B-30, and B-30a. Medical schools, which are discussed elsewhere, are included in the total but not in the college/university subtypes.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

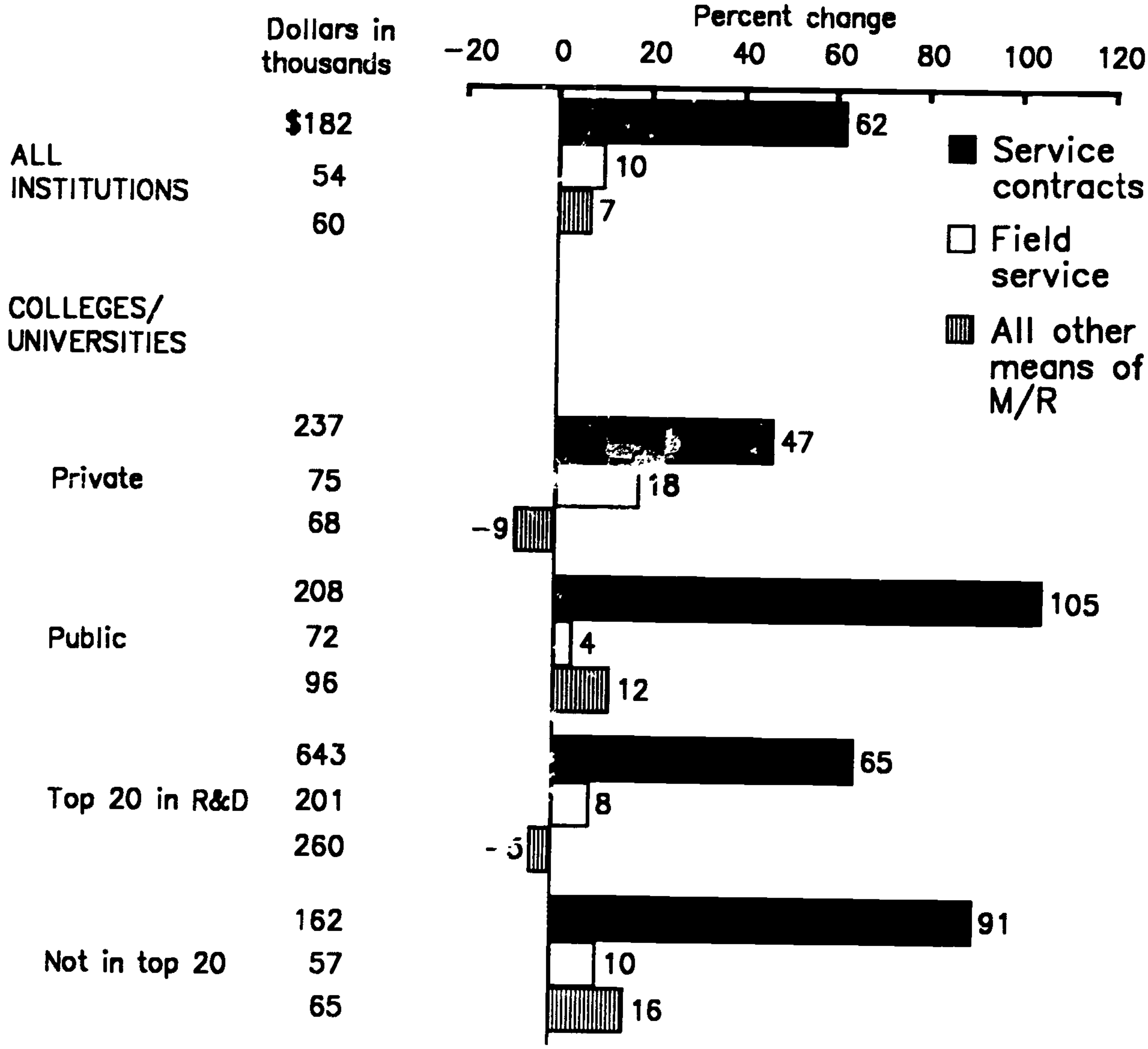
The composition of M/R expenditures has not remained constant, however: overall and for all institution types, annual expenditures for service contracts have increased far more than for other forms of M/R (Figure 4). This change reflects increases both in the average annual cost of service contracts (up from $3,200 per system in 1982-83 to $3,900 in 1985-86) and in the number (but not the proportion) of systems being maintained with service contracts (Table 9). Perhaps in compensation for these increasing service contract costs, the proportion of in-use systems that received no maintenance/repair service at all increased from 18 percent to 26 percent from 1982-83 to 1985-86 (Table 9). Some of these systems may be ones where the investigator cannot afford an additional service contract and is gambling that the instrument will not develop major problems in the immediate future. If so, some of these short-term economies may result in added M/R costs in future years.

Judging from investigators' assessments of systems' general working condition, there was little apparent change from 1982-83 to 1985-86 in the quality of the maintenance/repair being performed. The proportions of in-use systems judged to be in "excellent," "adequate," or "poor" condition were about the same in both surveys (Table 9).

The M/R findings for institutions in the top 20 in total R&D were quite similar to those for smaller R&D performers. The two categories of institutions had remarkably similar patterns in terms of types and average costs of M/R and also in terms of the general working condition of their equipment.

There were some M/R differences between public and private colleges/universities, however. In 1985-86, private institutions had service contracts on a larger fraction of their in-use equipment than did public institutions (26% vs. 19%), and M/R expenditures as a percent of total value of in-use equipment were higher at private than at public institutions (4.3% vs. 3.9%). On the other hand, public institutions increased their expenditures for service interests at a considerably higher rate than private institutions in the period 1982-83 to 1985-86 (120% vs. 47%).

Figure 4
Mean expenditures in 1985–86 per institution for maintenance/repair (M/R) of in-use equipment, by type of institution and type of M/R, and percent change from 1982–83[1]



[1]Medical schools, which are discussed elsewhere, are included in total but not in the college/university subtypes.

SOURCE: National Science Foundation, SRS

2. TRENDS IN THE PHYSICAL AND ENVIRONMENTAL SCIENCES

2.1 AMOUNT OF EQUIPMENT

This section discusses trend findings for three fields, each of which is comparatively large in terms of 1985-86 dollar amount of in-use research equipment: chemistry ($322 million), physics/astronomy ($221 million), and the environmental sciences ($170 million) (Table 10). Together, these three fields account for 36 percent of the dollar amount of all in-use research equipment in the S/E fields encompassed in this research.

Of these three fields, the environmental sciences -- geology and related disciplines -- experienced the greatest rate of growth in the value (aggregate purchase price) of its national stock of in-use research equipment, a 47 percent real increase from the 1982-83 level ($109 million). This is slightly above the increase for all S/E fields during this period (44%). Chemistry experienced a similarly high growth rate (44%) from its 1982-83 base of $210 million. Physics/astronomy, on the other hand, had one of the smallest increases of all S/E fields and subfields: up only 16 percent from its 1982-83 base of $180 million. Much research equipment in physics/astronomy is over this study's $1 million upper limit for detailed data collection, but the growth trends were even lower for these "big ticket" items, which actually declined in aggregate value (see Table 3, above).

The pattern is generally similar when quantitative change is measured in terms of numbers of in-use systems (Figure 5), although the growth rate for physics/astronomy is not quite as low on this measure (up 28%) as it is with measures of aggregate inventory value. The reason the number of in-use systems in physics/astronomy grew at a noticeably greater rate than the aggregate dollar amount of in-use equipment in this field is that physics/astronomy was one of the few fields where there was a substantial real decline in the average (mean) purchase price per in-use system, from $45,800 in 1982-83 to $41,700 in 1985-86, a reduction of 9 percent after adjustment for inflation (Table 10).

Another interesting indicator is obtained when department-reported annual expenditures for research equipment in a field are expressed as a percent of total annual R&D expenditures in the field. Across all of the fields encompassed in this study, 1985-86 expenditures

Table 10. Instrumentation amounts, prices, and expenditures in the physical and environmental sciences, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields	Physics/ astronomy	Chemistry	Environmental sciences
Number of systems in research use				
1982-83	36,300	3,900	4,800	2,100
1985-86	53,900	5,300	7,000	3,300
Percent change[2]	43%	28%	37%	50%
Aggregate purchase price of systems in research use (dollars in millions)				
1982-83	$1,311	$180	$210	$109
1985-86	$1,982	$221	$322	$170
Percent change[2]	44%	16%	44%	47%
Mean amount of in-use equipment per institution (dollars in millions)				
1982-83	$5.31	$1.16	$1.36	$0.70
1985-86	$7.45	$1.27	$1.85	$0.98
Percent change[2]	39%	11%	37%	40%
Mean price per system				
1982-83	$36,100	$45,800	$43,600	$51,600
1985-86	$36,800	$41,700	$45,900	$51,400
Percent change[2]	1%	-9%	4%	-2%
Annual expenditures for research equipment (in millions of dollars)				
1982-83	$413	$52	$39	$33
1985-86	$687	$89	$79	$52
Percent change[2]	48%	51%	76%	38%
Annual equipment expenditures as a percent of total R&D expenditures				
1982-83	8%	10%	13%	5%
1985-86	10%	12%	19%	7%

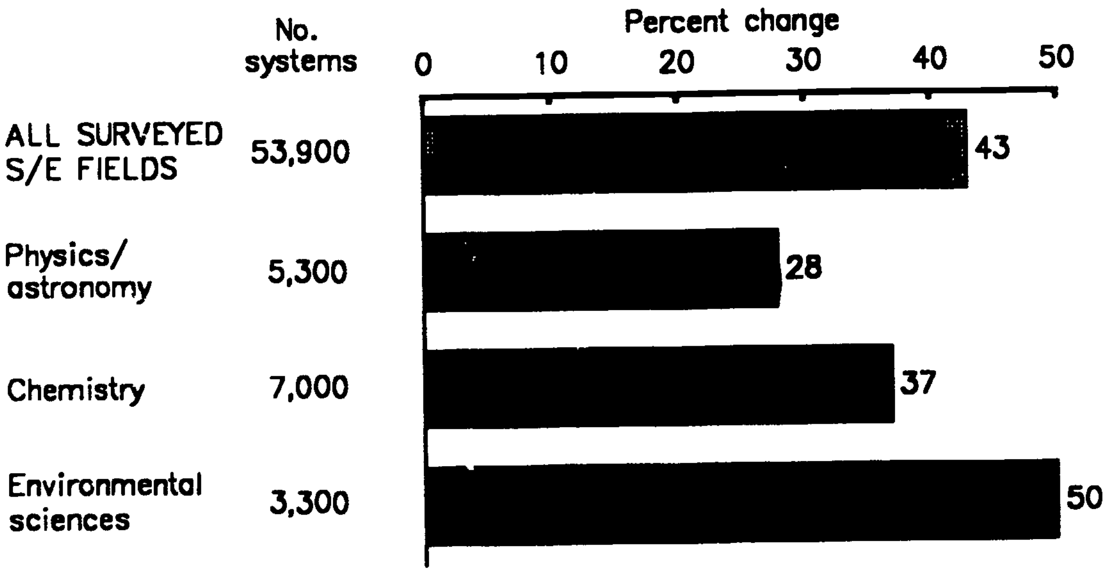
[1]From Appendix Tables B-7 to B-10, B-34 to B-35.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

for research equipment constituted 10 percent of total R&D expenditures, an increase from 8 percent in 1982-83 (Table 10). This finding of research equipment constituting a growing fraction of total R&D costs was also obtained in each of the three physical/environmental science fields.

Figure 5
Number of systems in research use in 1985–86 in the physical and environmental sciences and percent change since 1982–83



SOURCE: National Science Foundation, SRS

2.2 SOURCES OF FUNDS

In physics/astronomy, 87 percent of the research equipment in use in 1982-83 had been acquired with Federal funding support (see Appendix Table B-12). Chemistry and the environmental sciences were somewhat less dependent on Federal support, having obtained 64 percent and 57 percent, respectively, of their 1982-83 in-use systems with Federal funding support. These relative support levels remained essentially unchanged for chemistry and the environmental sciences, but in physics/astronomy the percent of systems with Federal funding support declined (by 12%) to 75 percent by 1985-86. Even at this reduced level, however, physics/astronomy showed a much higher dependence on Federal support than the overall average across all S/E fields, where 55 percent of in-use systems were acquired with Federal support. Since other types of support generally grew faster than Federal support, this helps provide one reason for the comparatively slow rate of instrumentation growth in physics/astronomy.

In real dollar terms, the Federal contribution to the total stock of in-use research equipment in physics/astronomy remained essentially the same from 1982-83 to 1985-86, overall and for all three of the field's major funding sources: the Department of Energy (DOE) (no real increase), NSF (1% increase), and the Department of Defense (DOD) (13% increase) (Table 11). This is considerably below the overall trend in Federal support, which grew by 30 percent across all S/E fields. Physics/astronomy also remained essentially static in funding from business/donation sources (up 2%) and from foundation/other sources (down 6%). Perhaps partly in compensation for the relative decline in these outside sources of support for physics/astronomy, university funding increased at a far above-average rate (80%), as did funding from State government (up several hundred percent from a small base in 1982-83), but these increases were not sufficient to enable physics/astronomy to keep pace with other S/E fields.

In contrast to the above, chemistry enjoyed substantial real increases in instrumentation funding from all of its principal sources of Federal support: NSF (up 22%), NIH (up 64%), DOE (up 186%), and DOD (up 54%). All nonfederal sources also had above-average increases in chemistry (Table 11).

Of the three physical/environmental science fields, the environmental sciences had the greatest overall rate of growth in Federal support: up 45 percent (Figure 6). This includes major real increases from NSF (up 71%), DOE (up 70%), and DOD (up 44%). Support from local institution funds was also up an above-average 53 percent in the environmental sciences.

Table 11. Sources of funds for the purchase of in-use systems in the physical and environmental sciences, 1982-83 to 1985-86[1]

Source of funds	All surveyed S/E fields		Physics/ astronomy		Chemistry		Environmental sciences	
	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]
	(dollars in millions)							
Total, all reported sources	$1,884	42%	$209	13%	$305	44%	$166	47%
All Federal sources	$906	30%	$141	1%	$158	39%	$78	45%
NSF	$306	26%	$54	1%	$85	22%	$30	71%
NIH	$270	46%	$1	*	$32	64%	$<1	*
DOD	$142	28%	$28	13%	$15	54%	$10	44%
DOE	$90	36%	$29	0%	$17	186%	$15	70%
All other	$99	9%	$30	-6%	$8	11%	$22	13%
All non-Federal sources	$978	55%	$67	53%	$148	49%	$88	48%
Institution funds	$580	47%	$46	80%	$96	30%	$45	53%
State government	$114	72%	$4	*	$14	132%	$11	36%
Business/private donations	$239	69%	$14	2%	$28	78%	$27	39%
Other	$45	61%	$3	-6%	$9	*	$5	*

[1]From Appendix Tables B-13 to B-14a.

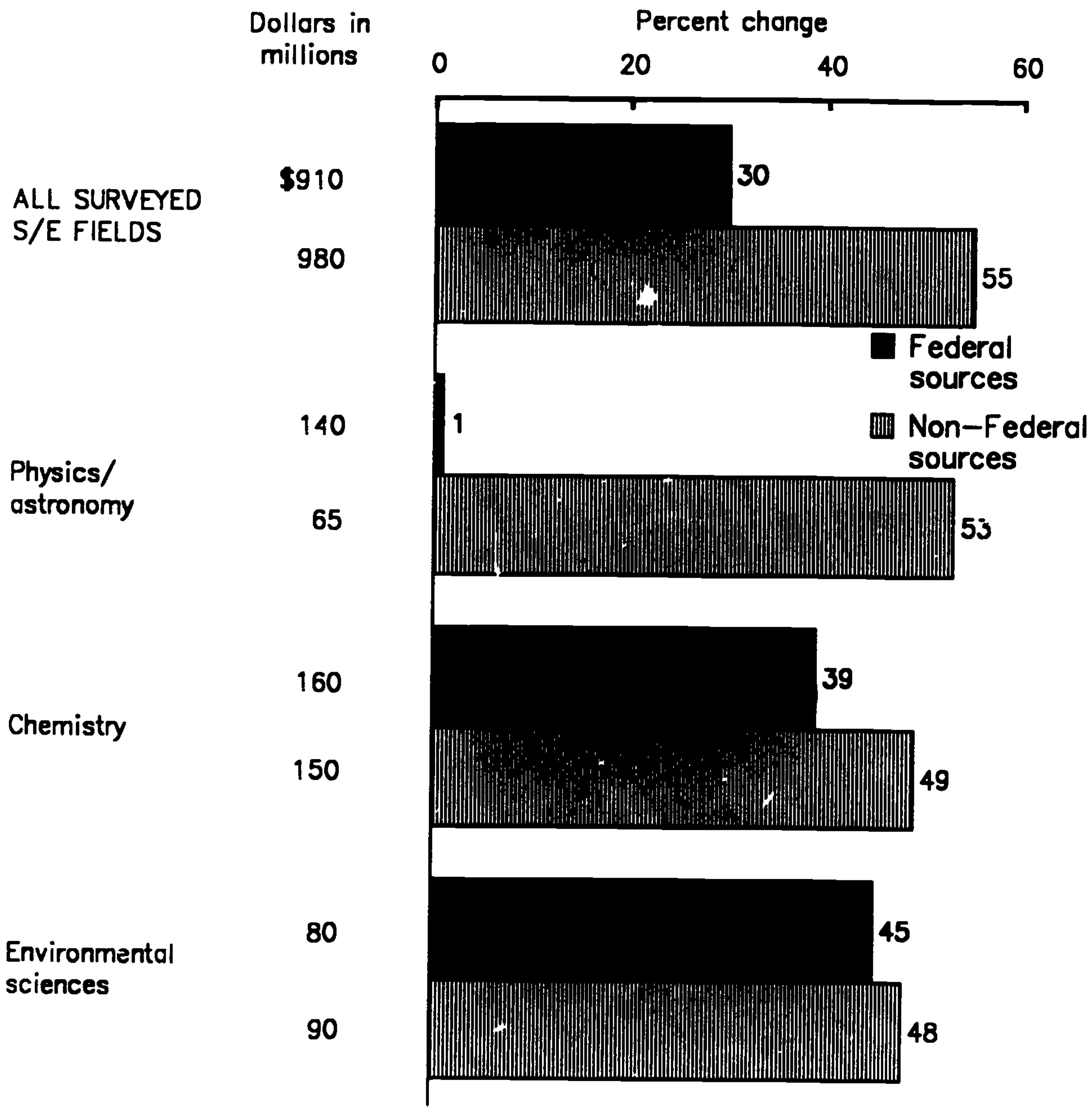
[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

*Unstable percentage: 1982-83 base is less than $4 million.

SOURCE: National Science Foundation, SRS

4 3

Figure 6
Aggregate purchase price of in–use research equipment in 1985–86 in the physical and environmental sciences, by source of funds, and percent change from 1982–83



SOURCE: National Science Foundation, SRS

2.3 QUALITY/ADEQUACY

Equipment Quality

One indicator of qualitative improvement in instrumentation stocks is the finding that there are substantial increases -- over 200 percent -- in the dollar amount of equipment that is under construction/development for future research use in all three physical/environmental science fields (Table 12). In two of these fields, chemistry and the environmental sciences, there are also very high rates of growth in the aggregate dollar amount of state-of-the-art equipment (70% and 65%, respectively). In the third field, physics/astronomy, the increase in state-of-the-art equipment was not particularly large (19%), which suggests that there has not been any great qualitative improvement in that field's instrumentation stocks. Even in physics/astronomy, however, the growth in advanced instrumentation was more rapid than it was for other (less advanced) equipment (Figure 7).

Table 12. Composition of research equipment inventories in the physical and environmental sciences, 1982-83 to 1985-86[1]

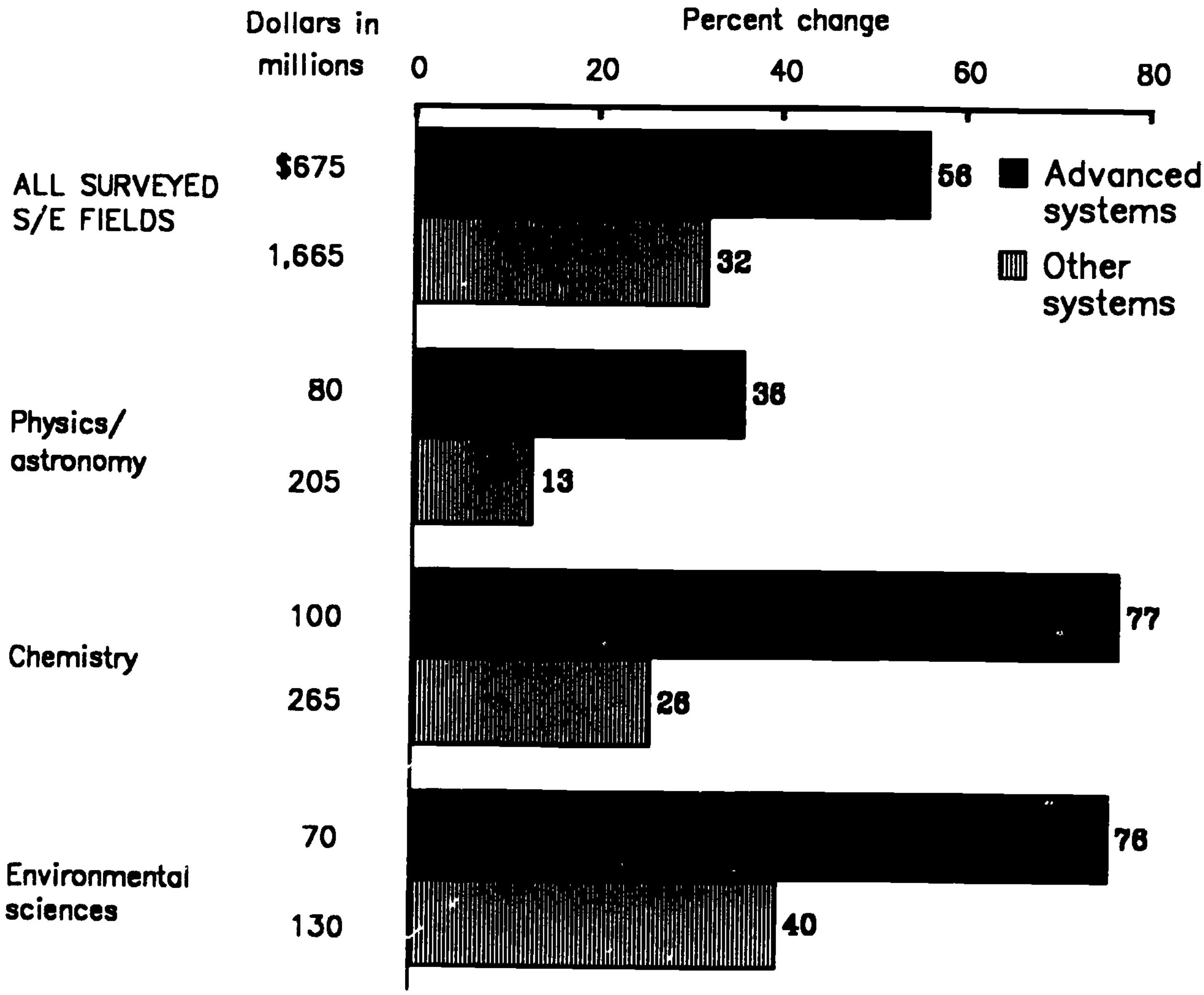
Inventory component	All surveyed S/E fields		Physics/ astronomy		Chemistry		Environmental sciences	
	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]
	(dollars in millions)							
Total, all systems	$2,342	38%	$283	19%	$370	36%	$200	50%
Advanced systems	$677	56%	$80	36%	$100	77%	$70	76%
Not yet in use	$82	136%	$14	200+%	$8	200+%	$8	200+%
State-of-the-art	$595	50%	$65	19%	$91	70%	$61	65%
Other systems	$1,666	32%	$204	13%	$267	26%	$130	40%
Other in-use	$1,387	41%	$156	15%	$231	35%	$108	38%
Inactive/inoperable	$279	1%	$48	8%	$36	-13%	$22	51%

[1]Derived from Appendix Tables B-4 and B-4a.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Figure 7
Aggregate purchase price of the 1985–86 stock of research equipment in the physical and environmental sciences, by system status,[1] and percent change from 1982–83



[1] Advanced systems include ones that are still under development and not yet in use, plus in–use systems that are judged by their users to be state–of–the–art. Other systems include in–use systems that are not state–of–the–art, plus inactive/inoperable systems.

SOURCE: National Science Foundation, SRS

52

Adequacy of Existing Research Equipment

As noted earlier, extensive use of non state-of-the-art research equipment is not necessarily indicative of inadequate instrumentation, as long as the researchers who use non-state-of-the-art equipment also have access to more advanced instrumentation when it is needed. In this respect, all three physical/environmental fields appear to have improved: in all three, the percent of non-state-of-the-art systems whose users have access to more advanced instrumentation when needed increased by about 10 percentage points from 1982-83 to 1985-86 (Table 13).

In chemistry, the percent of department chairpersons who assessed their research equipment as being generally "insufficient" to permit faculty investigators to pursue their major research interests declined markedly from 1982-83 to 1985-86 (from 49% to 29%), a greater improvement in perceived adequacy of existing equipment than found for any other S/E field (Table 13). This finding is consistent with other indicators of increased quantity, improved quality, wide-ranging funding support, and generally improving circumstances for research equipment in chemistry. In physics/astronomy and the environmental sciences, department heads' assessments of the adequacy of existing equipment changed very little between 1982-83 and 1985-86 (Table 13).

Table 13. Adequacy of the research equipment in the physical and environmental sciences, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields		Physics/ astronomy		Chemistry		Environmental sciences	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Percent of non-state-of-the-art systems whose users also have access to more advanced systems when needed	54%	62%	55%	65%	48%	57%	53%	63%
Percent of department heads assessing the overall adequacy of the research equipment available to their faculty as:								
Excellent	11%	11%	2%	10%	6%	13%	9%	10%
Adequate	54%	54%	65%	55%	45%	58%	64%	59%
Insufficient	36%	35%	33%	35%	49%	29%	27%	31%

[1]From Appendix Tables B-20 and B-31.

SOURCE: National Science Foundation, SRS

2.4 USAGE PATTERNS

In physics/astronomy, there was a slight reduction in the proportion of research equipment located in within-department labs of individual investigators (from 69% to 66% of in-use systems) and a corresponding increase in the proportion of equipment in department-managed common labs (from 17% to 21%). Chemistry and the environmental sciences did not show such a shift (Table 14).

Table 14. Patterns of equipment usage in the physical and environmental sciences, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields		Physics/ astronomy		Chemistry		Environmental sciences	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Percent of in-use systems located in:								
Within-department labs of individual principal investigators (PI's)	59%	56%	69%	66%	62%	63%	52%	51%
Department managed common labs	32%	31%	17%	21%	30%	29%	28%	28%
Other shared-access locations	8%	13%	15%	13%	7%	8%	20%	22%
Percent of in-use systems that are:								
Dedicated for use in a specific experiment or series of experiments	27%	31%	48%	51%	31%	35%	33%	42%
Available for general purpose use	73%	69%	52%	49%	69%	65%	67%	58%
Mean number of users per system								
All in-use systems	14	14	12	14	19	16	12	11
Dedicated	8	8	7	9	9	6	7	8
General purpose	16	17	15	19	24	20	15	14

[1]From Appendix Tables B-21, B-24, and B-26.

SOURCE: National Science Foundation, SRS

Overall, there was a modest shift toward increasing dedication of equipment to specific experiments or series of experiments, which was evident in all three physical/environmental science fields (Table 14).

Consistent with the pattern of generally improving circumstances in chemistry, the average (mean) number of research users per system per year declined measurably in that field, from 19 in 1982-83 to 16 in 1985-86. Physics/astronomy and the environmental sciences evidenced no particular change in average numbers of users (Table 14).

2.5 MAINTENANCE AND REPAIR

Total annual expenditures for maintenance and repair of research equipment increased by 37 percent in the environmental sciences, more than in chemistry (up 23%) or physics/astronomy (up 22%) (Table 15). The general trend noted earlier for all S/E fields was toward increasing reliance on comparatively expensive service contracts, with corresponding shifts away from in-house maintenance/repair and other forms of M/R. These trends were evident in all three physical/environmental science fields. They were especially pronounced in physics/astronomy, where expenditures for service contracts more than doubled and expenditures for other forms of M/R actually declined (Figure 8).

All three physical/environmental science fields had increasing proportions of equipment that were receiving no M/R at all (Table 15). There was no indication that this lack of service had adversely affected the general working condition of the research equipment in these fields, however. In fact, the percent of in-use systems judged to be in poor working condition actually declined in all three fields.

Table 15. Maintenance and repair (M/R) of research equipment in the physical and environmental sciences, 1982-83 to 1985-86[1]

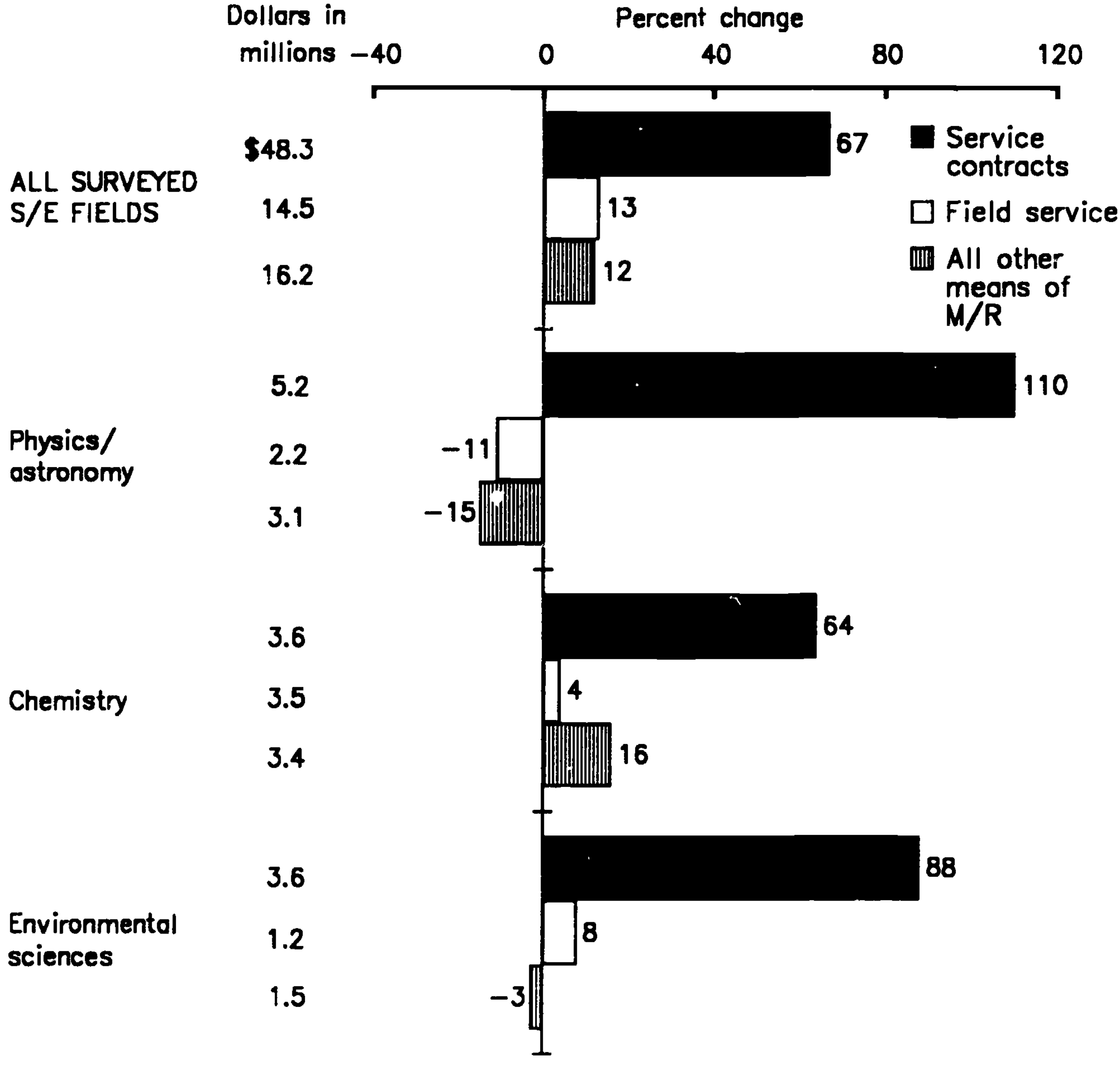
Index	All surveyed S/E fields		Physics/ astronomy		Chemistry		Environmental sciences	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Annual expenditures for M/R								
Total (dollars in millions)	$50.0	$79.0	$7.5	$10.5	$7.5	$10.5	$4.1	$6.3
Percent change from 1982-83[2]		41%		22%		23%		37%
M/R expenditures as a percent of system purchase price	3.8%	4.0%	4.2%	4.7%	3.6%	3.3%	3.8%	3.7%
Annual expenditures for service contracts								
Total (dollars in millions)	$25.7	$48.3	$2.2	$5.2	$1.9	$3.6	$1.7	$3.6
Percent change from 1982-83[2]		67%		110%		64%		88%
Annual expenditures for all other forms of M/R								
Total (dollars in millions)	$24.3	$30.7	$5.3	$5.2	$5.6	$7.0	$2.4	$2.7
Percent change from 1982-83[2]		12%		-14%		10%		1%
Percent of in-use systems with M/R from:								
Service contracts	24%	24%	7%	17%	9%	10%	14%	15%
Other means of service	58%	50%	73%	51%	77%	65%	68%	61%
No M/R was required	18%	26%	21%	31%	14%	26%	19%	24%
Mean annual M/R expenditures per system (dollars in thousands)								
Service contracts	$3.2	$3.9	$8.7	$5.4	$5.0	$4.9	$6.4	$6.8
All other means of M/R	$2.5	$2.5	$4.7	$4.6	$3.5	$3.3	$3.9	$2.9
General working condition of in-use systems (percent of systems)								
Excellent	52%	55%	53%	54%	51%	53%	50%	67%
Adequate	38%	38%	35%	41%	35%	39%	42%	28%
Poor	10%	7%	12%	5%	14%	8%	8%	5%

[1]From Appendix Tables B-8, B-17, B-27, B-27a, B-28, B-28a, B-30, and B-30a.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Figure 8
Expenditures for maintenance and repair (M/R) of in-use equipment in the physical and environmental sciences in 1985-86, by type of M/R, and percent change from 1982-83



SOURCE: National Science Foundation, SRS

3. TRENDS IN ENGINEERING, COMPUTER SCIENCE, AND MATERIALS SCIENCE

This chapter highlights trend findings for engineering and two closely related fields, computer science and materials science. Within engineering, three subdivisions are discussed: electrical engineering, mechanical engineering, and the combination of all other engineering disciplines. Additional detail for some of the smaller engineering disciplines is presented in the Appendix B tables.

The computer science category contains instrument systems that were described by the responsible principal investigator (PI) as being used for research in this field. Most research equipment from departments of computer science was so classified, and some equipment from electrical engineering departments also was classified in this category.

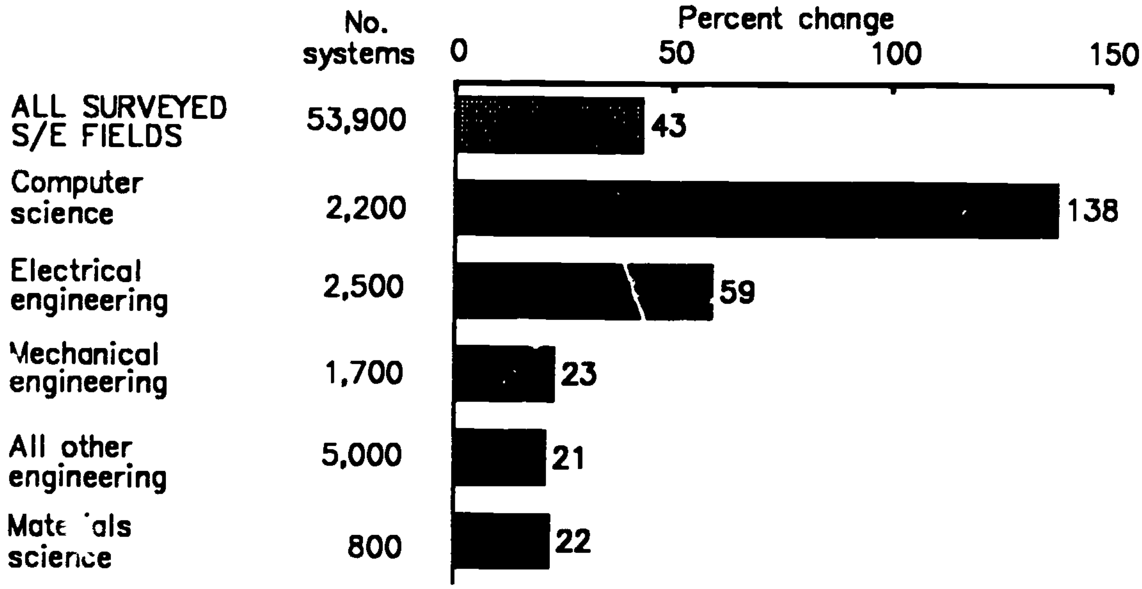
Most instrumentation in the study's materials science category was obtained from a few large nondepartmental units specifically devoted to materials science research, especially NSF-funded Materials Research Laboratories (MRL's). Equipment from departments in the closely allied field of materials engineering was classified in the engineering category, unless the PI specifically described the system's principal field of research use as being materials science. Similarly, equipment located in physics or chemistry departments for use in areas such as superconductivity or condensed matter research was classified in the materials science category only if that specific designation was given by the reporting PI.

3.1 AMOUNT OF EQUIPMENT

Computer science, engineering, and materials science each showed different patterns of growth in scientific research equipment. Computer science grew at a faster rate than any other field included in this survey, from 900 to 2,200 instruments in research use, a real growth rate of 138 percent (Figure 9). This was much greater than the average growth rate of 43 percent across all science and engineering fields. Electrical engineering, which is closely allied to computer science at many institutions, also had an above average increase (59%), while mechanical engineering and other engineering fields[1] grew less rapidly (23% and 21%, respectively). Materials science also had a below average expansion (22%) of its in-use research instrumentation stock.

[1] Other fields of engineering include chemical, civil, metallurgical/materials, and smaller fields such as aeronautical, agricultural, biomedical, industrial, nuclear, textile, etc.

Figure 9
Number of systems in research use in 1985–86 in computer science, engineering, and materials science and percent change from 1982–83



SOURCE: National Science Foundation, SRS

The 138 percent increase in computer science, though exceptional, actually understates the pace of turnover in computer science research equipment. The rapid growth occurred despite the fact that computer science had the highest retirement rate of older equipment of any field in the study (42% of the research equipment in use in 1982-83 had been retired from research service by 1985-86), so that 75 percent of all equipment in use in 1985-86 had been acquired over the prior three years (again, the greatest rate of acquisition of new equipment of any field) (Table 16). These marked changes may reflect changes in the importance of computers for scientific research, as well as changes in technology that led both to the availability of more powerful computing equipment and to the relative obsolescence of older equipment. These findings are consistent with the data reported above regarding massive increases in academic and research computer centers, and they appear to indicate that computing equipment and computer-related R&D are becoming increasingly prominent in academic science and engineering.

Materials science, in contrast, had lower than average equipment turnover: thus, only 17 percent of systems in-use in 1982-83 were retired from research use by 1985-86, and only 23 percent of the equipment in use in 1985-86 had been acquired over the last three years.

Table 16. Equipment retirement and acquisition rates in computer science, engineering, and materials science, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields	Computer science	Engineering			Materials science
			Electrical	Mechanical	All other	
Retirements						
Of systems in research use in 1982-83, percent retired in 3-year period from 1982-83 to 1985-86	23%	42%	31%	33%	23%	17%
Acquisitions						
Of systems in research use in 1985-86, percent acquired in 3-year period from 1982-83 to 1985-86	37%	75%	44%	36%	'2%	23%

[1]See Appendix Table B-6.

SOURCE: National Science Foundation, SRS

Engineering again showed mixed results, with electrical engineering showing the most change (a 31 percent retirement rate, and a 44 percent new acquisition rate), and mechanical and other engineering showing lesser changes.

There was a total of $372 million of in-use research equipment in engineering in 1985-86, which represents a net real growth of 34 percent from the 1982-83 figure of $261 million (see Appendix Table B-8). This increase is well below the overall average for all S/E fields, 44 percent. Within engineering, however, there were some pronounced differences among fields.

Though computer science grew most rapidly, engineering showed a greater absolute increase in the number of systems and in the total dollar value. Starting from a much larger base (6,800 systems in 1982-83, with a value of $261.3 million), engineering expanded to 9,300 systems and $371.8 million. Within engineering, the number of in-use systems in electrical engineering grew at an above average rate of 59 percent, while the numbers of systems in mechanical and other engineering had lower than average increases (23% and 21%, respectively) (Table 17). Electrical engineering's relatively rapid rate of expansion has increased its prominence within engineering, increasing from 22 to 27 percent of all in-use systems in engineering.

Table 17. Instrumentation amounts, prices, and expenditures in computer science, engineering, and materials science, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields	Computer science	Engineering			Materials science
			Electrical	Mechanical	All other	
Number of systems in research use						
1982-83	36,300	900	1,500	1,300	3,900	600
1985-86	53,900	2,200	2,500	1.700	5,000	800
Percent change[2]	43%	138%	59%	23%	21%	22%
Aggregate purchase price of systems in research use (dollars in millions)						
1982-83	$1,311	$50	$65	$51	$146	$34
1985-86	$1,982	$100	$110	$71	$191	$45
Percent change[2]	44%	85%	59%	32%	23%	26%
Mean amount of in-use equipment per institution (dollars in millions)						
1982-83	$5.31	$0 32	$0.42	$0.33	$0.94	$0.22
1985-86	$7.45	$0.58	$0.63	$0.41	$1.10	$0.26
Percent change[2]	39%	76%	51%	25%	17%	20%
Mean price per system						
1982-83	$36,100	$57,800	$42,400	$37,600	$37,200	$53,000
1985-86	$36,800	$46,000	$43,300	$40,600	$38,300	$55,300
Percent change[2]	1%	-22%	0%	7%	1%	3%
Annual expenditures for research equipment (dollars in millions)						
1982-83	$413	$29	$46	$19	$90	$12
1985-86	$687	$66	$59	$32	$126	$10
Percent change[2]	48%	96%	15%	49%	11%	-24%
Annual equipment expenditures as a percent of total R&D expenditures						
1982-83	8%	13%	14%	6%	7%	--
1985-86	10%	17%	14%	11%	11%	--

[1]From Appendix Tables B-7 to B-10, B-34, and B-35.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F

SOURCE: National Science Foundation, SRS

3.2 SOURCES OF FUNDS

In 1982-83, 53 percent of the in-use instrument systems in engineering had been acquired, partly or entirely, with Federal funding support (see Appendix Table B-12). By 1985-86, this figure had dropped to 46 percent. The relative decline in Federal support was especially pronounced in electrical engineering, which had Federal funding support for 74 percent of its 1982-83 equipment but only 52 percent of its 1985-86 equipment, a drop of 22 percentage points. On the other hand, Federal funding support for equipment in the closely allied field of computer science increased from 54 percent to 59 percent of in-use systems. This was due to a great increase in systems that were funded entirely by Federal sources (from 27% to 54%), while the percentage of systems receiving partial Federal funding dropped from 27 percent to 5 percent. Materials science showed a slight decline in the percentage of systems receiving Federal funding, from 87 percent in 1982-83 to 80 percent in 1985-86. Both materials science and computer science had a greater percentage of systems receiving Federal funding than the overall average (55%), while engineering was below the average.

In 1985-86, the greatest amounts of Federal instrumentation support for engineering came from DOD (43%), NSF (28%), and DOE (12%) (Table 18). In real dollar terms, engineering had below average rates of growth from all three sources, with NSF up only 1 percent from its 1982-83 level, DOD up 16 percent (as compared to its overall increase of 28% across all S/E fields), and DOE up 15 percent (compared with 36% overall). Mechanical engineering fared especially poorly in terms of NSF support (down 12%), while electrical and other engineering had NSF increases of 4 and 5 percent, respectively. Mechanical engineering performed somewhat better in terms of DOD support, with a slightly below average 23 percent increase, while DOD support for electrical and other engineering grew at lower rates (11% and 18%, respectively).

In electrical engineering, the comparatively small increase in Federal instrumentation support was offset by a substantial increase (101%) in support from institution funds and by an even larger increase (187%) in donations of or for research equipment from business and private sources, which grew from $11.6 million in 1982-83 to $35.7 million in 1985-86. Other fields of engineering generally experienced below-average funding increases from non-Federal sources.

The growth in computer science instrumentation was led by a substantial (109%) increase in Federal funding support (Figure 10), with over 90 percent of these funds coming primarily from NSF (up 123%) and DOD (up 99%). This field also received above-average increases from institution funds (up 71%) and from business/private donations (up 61%).

Materials science was below average in its funding increases both from Federal and non-Federal sources.

Table 18. Sources of funds for purchase of in-use systems in computer science, engineering, and materials science, 1982-83 to 1985-86[1]

Source of funds	All surveyed S/E fields		Computer science		Engineering: Electrical		Engineering: Mechanical		Engineering: All other		Materials science	
	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]
	(dollars in millions)											
Total, all reported sources	$1,884	42%	$94	74%	$107	66%	$69	31%	$184	21%	$41	15%
All Federal sources	$906	30%	$49	109%	$41	3%	$26	4%	$70	25%	$26	5%
NSF	$306	26%	$26	123%	$11	4%	$7	-12%	$20	5%	$18	33%
DOD	$142	28%	$20	99%	$23	11%	$16	23%	$20	18%	$3	-49%
DOE	$90	36%	$1	*	$2	*	$1	*	$14	45%	$4	*
All other	$368	34%	$3	*	$5	-19%	$2	*	$15	58%	$1	*
All non-Federal sources	$978	55%	$45	47%	$66	166%	$43	57%	$114	19%	$15	40%
Institution funds	$580	47%	$22	71%	$23	101%	$20	34%	$64	9%	$10	61%
State government	$114	72%	$3	-42%	$7	*	$8	*	$14	12%	$1	*
Business/private donations	$239	69%	$20	61%	$36	187%	$13	52%	$32	43%	$2	*
Other	$45	61%	$<1	*	$1	*	$2	*	$5	*	$2	*

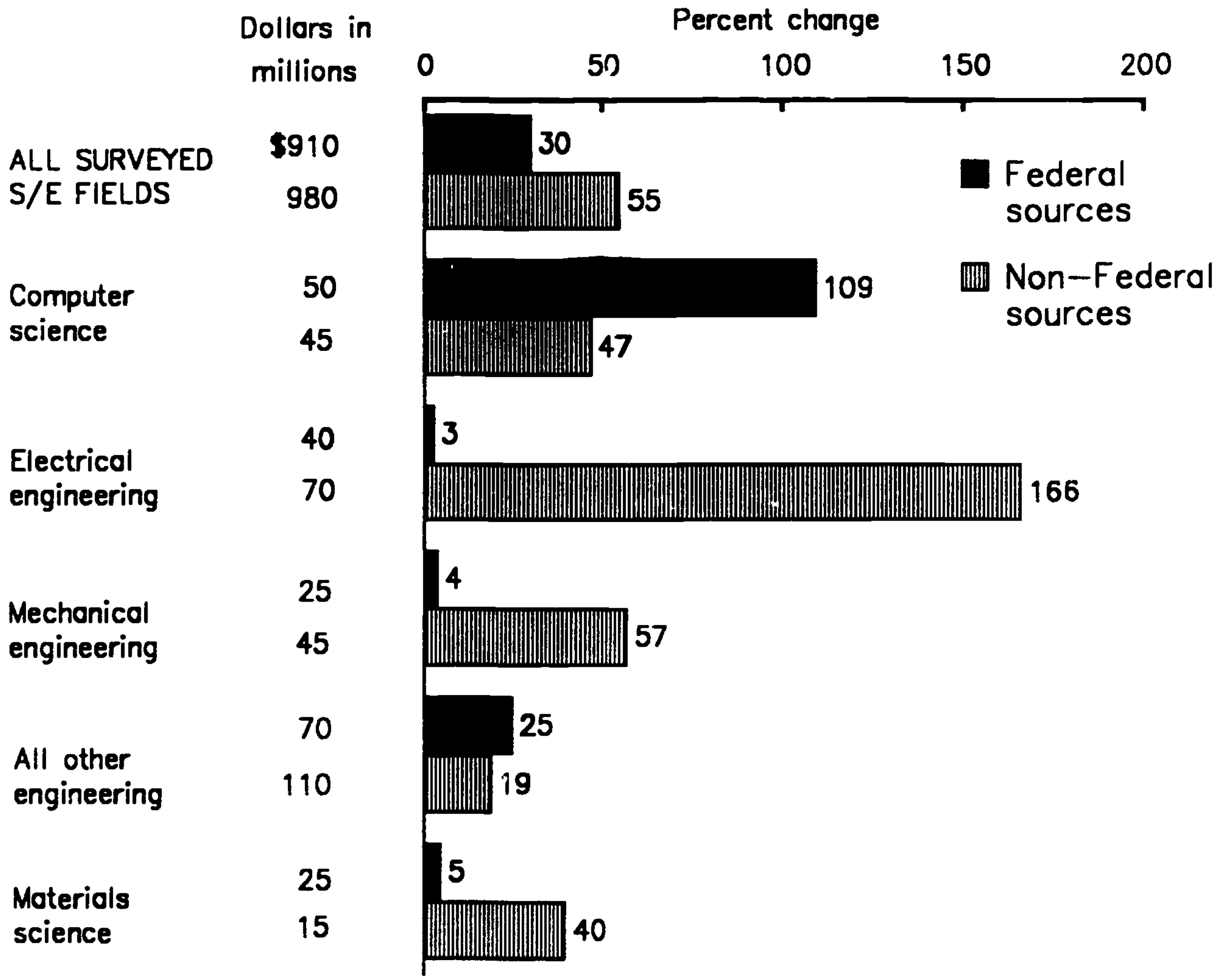
[1] See Appendix Tables B-13, B-13a, B-14, B-14a

[2] Estimates are adjusted for inflation For procedure, see Appendix F

*Unstable percentage: 1982-83 is less than $4 million.

SOURCE: National Science Foundation, SRS

Figure 10
Aggregate purchase price of equipment in use in 1985–86 in computer science, engineering, and materials science, and percent change from 1982–83, by source of funds



SOURCE: National Science Foundation, SRS

64

3.3 QUALITY/ADEQUACY

Equipment Quality

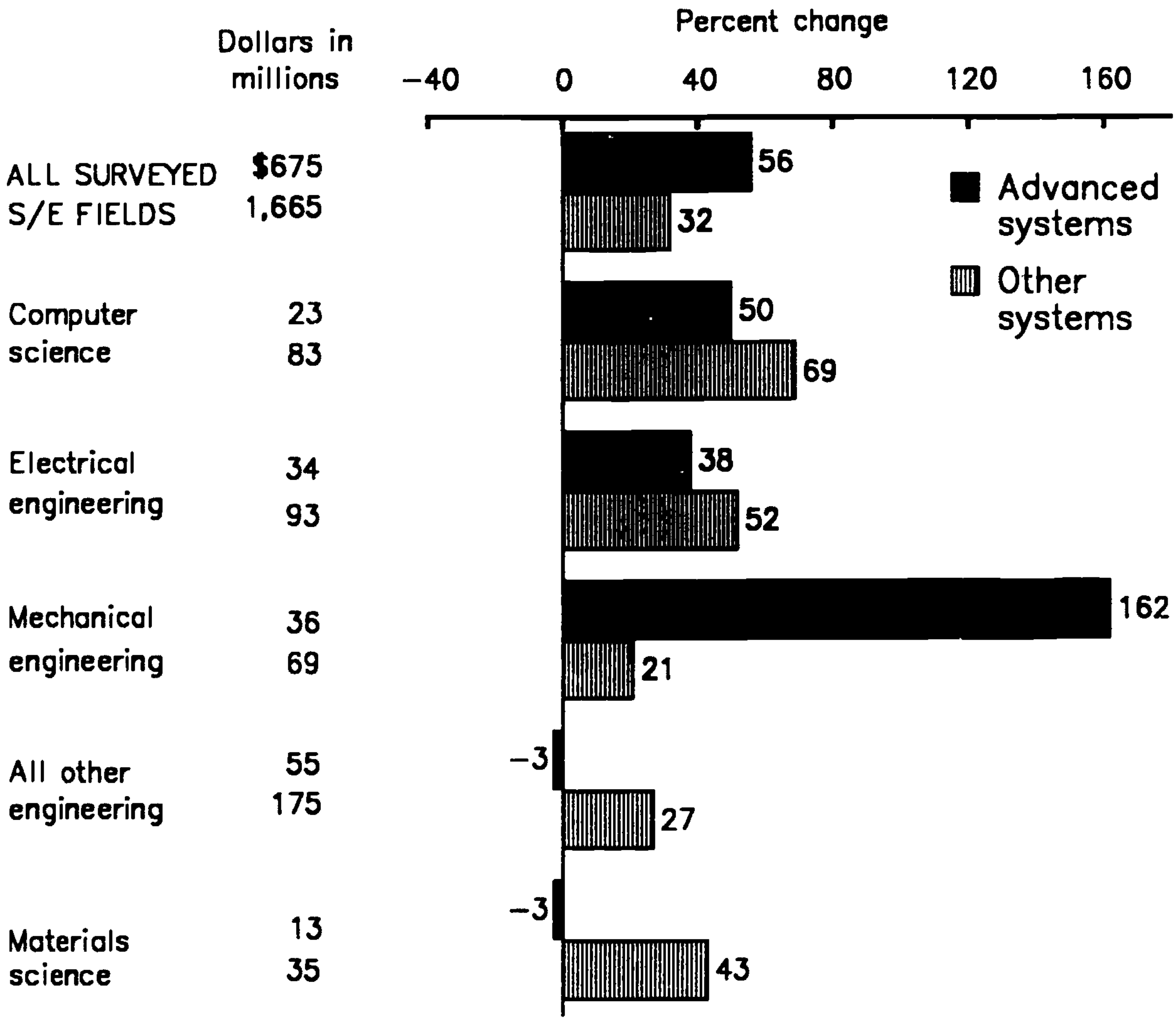
As noted earlier, one indicator of trends in the quality of research equipment is based on relative rates of growth of advanced equipment (equipment that is not yet in use or is state-of-the-art) as compared to other in-use equipment and inactive/inoperable equipment. This indicator does not work well in the case of computer science, however, where equipment is changing so rapidly that the median age of state-of-the-art equipment is one year or less, and where the median age of all other equipment in research use is only slightly higher: two years (see Appendix Table B-5). Under these circumstances, it is hard to accumulate a large stock of state-of-the-art equipment over time, and having a comparatively high growth rate for other in-use equipment is not indicative of any decline in the quality of the national stock of research equipment in the field (Figure 11).

For the same reasons, the related field of electrical engineering is also a special case. There, too, state-of-the-art research equipment is changing so rapidly that it would be unrealistic to look for a progressive accumulation of such equipment over time or to expect state-of-the-art equipment to grow at the same pace as other research equipment.

Mechanical engineering is a different story. In that field, there has been a virtual explosion of "advanced" equipment from 1982-83 to 1985-86 (i.e., state-of-the-art equipment and equipment that has been purchased and is in the pipeline but has not yet been used for research). The net dollar amount of this equipment more than doubled during this three-year period (Figure 11), while the national stocks of less advanced equipment in this field grew only 21 percent. These results seem to suggest that some major retooling or other qualitative change in instrumentation needs and purchasing patterns is occurring in mechanical engineering.

Yet another pattern was found for materials science and for the aggregated "other" (smaller) fields of engineering. In both of these categories, there were net real declines in the dollar value of the national stocks of advanced research equipment, and the only areas where even modest growth was seen were ones involving less-than-advanced equipment (Table 19).

Figure 11
Amount of research equipment in 1985–86 in computer science, engineering, and materials science, by equipment status, and percent change from 1982–83 [1]



[1] Advanced systems include ones that are still under development and not yet in use, plus in-use systems that are judged by their users to be state-of-the-art. Other systems include in-use systems that are not state-of-the-art, plus inactive/inoperable systems.

SOURCE: National Science Foundation, SRS

Table 19. Composition of research equipment inventories in computer science, engineering, and materials science, 1982-83 to 1985-86[1]

Inventory component	All surveyed S/E fields		Computer science		Engineering: Electrical		Engineering: Mechanical		Engineering: All other		Materials science	
	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]
	(dollars in millions)											
Total, all systems	$2,342	38%	$106	65%	$126	47%	$105	48%	$230	19%	$48	26%
Advanced systems	$677	56%	$23	50%	$34	38%	$36	162%	$55	-3%	$13	-3%
Not yet in use	$82	136%	$2	*	$3	*	$13	*	$5	-48%	$2	*
State-of-the-art	$595	50%	$21	75%	$31	39%	$23	98%	$50	5%	$11	-11%
Other systems	$1,666	32%	$83	69%	$93	52%	$69	21%	$175	27%	$35	43%
Other in-use	$1,387	41%	$80	87%	$79	69%	$48	14%	$142	30%	$33	46%
Inactive/inoperable	$279	1%	$3	*	$14	-7%	$22	41%	$33	17%	$2	*

[1] See Appendix Tables B-4 and B-4a.

[2] Estimates are adjusted for inflation. For procedure, see Appendix F.

*Unstable percentage: 1982-83 is less than $6 million.

SOURCE National Science Foundation, SRS

Adequacy of Existing Research Equipment

In computer science, there was an especially large (17 percentage point) increase from 1982-83 to 1985-86 in the reported percentage of non state-of-the-art systems whose research users have access to more advanced equipment when needed (Table 20). This positive development is consistent with other observed indicators for this field. On this indicator, materials science and all three engineering fields also showed changes that, while smaller in magnitude, were positive in direction.

As might be expected, the percent of computer science department heads who characterized their research equipment stocks as being generally excellent -- in the sense of enabling department faculty to pursue their major research interests -- increased substantially, from 2 percent in 1982-83 to 13 percent in 1985-86 (Table 20). In electrical and mechanical engineering, however, even larger changes were observed in the opposite direction. In these fields, the percentages of department heads describing their existing equipment stocks as excellent

Table 20. Adequacy of the research equipment in computer science, engineering, and materials science, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields		Computer science		Engineering: Electrical		Engineering: Mechanical		Engineering: All other		Materials science	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Percent of non-state-of-the-art systems whose users also have access to more advanced systems when needed	54%	62%	50%	67%	59%	62%	50%	60%	47%	53%	65%	72%
Percent of department heads assessing the overall adequacy of the research equipment available to their faculty as:												
Excellent	11%	11%	2%	13%	20%	2%	19%	1%	4%	6%	24%	27%
Adequate	54%	54%	52%	44%	22%	40%	27%	31%	48%	49%	62%	65%
Insufficient	35%	35%	45%	44%	58%	58%	54%	68%	47%	45%	14%	9%

[1]See Appendix Tables B-20 and B-31.

SOURCE: National Science Foundation, SRS

plummeted from 19-20 percent in 1982-83 to 1-2 percent in 1985-86, suggesting that the observed increases in equipment amounts during this period have not produced any widespread enhancement in faculty ability to conduct frontier research.

In the other (smaller) fields of engineering, there was no particular drop in the proportion of department heads reporting excellent equipment stocks. Very few department heads in this field category had reported excellent stocks in 1982-83 (4%), and about the same percentage (6%) gave that assessment in 1985-86 (Table 20).

Heads of materials science research installations (most of which were interdepartmental research centers rather than academic departments) were among the most satisfied with their existing research equipment. Only 9 percent said their equipment was insufficient (down from 14%), and 27 percent indicated that their equipment was excellent (up from 24%). This seems odd, given the relatively sluggish equipment growth rates noted earlier for this field. The explanation offered by administrators of some of the larger Materials Research Labs (MRL's) in the study is that, while there has been a gradual decline since 1982 in the total number of Federally funded MRL's, the MRL's that remain in operation have continued to be well funded.

3.4 USAGE PATTERNS

In electrical engineering, which experienced an above-average rate of instrumentation growth, the average number of users per system per year declined from 21 to 19 (Table 21). Consistent with their lower rates of growth, mechanical and other fields of engineering experienced increases in their average numbers of users (from 9 to 11 in mechanical engineering, and from 11 to 13 in other fields).

Computer science and materials science both experienced declines in the average number of users (from 49 to 46, and from 24 to 19, respectively). This decline may be another factor that helps explain the increasing satisfaction with equipment found in both areas.

Table 21. Patterns of equipment usage in computer science, engineering, and materials science, 1982-83 to 1985-86[1]

Source of funds	All surveyed S/E fields		Computer science		Engineering: Electrical		Engineering: Mechanical		Engineering: All other		Materials science	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
	(dollars in millions)											
Percent of in-use systems located in:												
Within-department labs of individual principal investigators (PI's)	59%	56%	20%	37%	67%	50%	43%	49%	46%	[illegible]	19%	23%
Department-managed common labs	[illegible]	31%	65%	53%	21%	36%	44%	43%	46%	35%	27%	29%
Other shared-access locations	8%	13%	15%	10%	12%	14%	13%	8%	8%	16%	54%	49%
Percent of in-use systems that are:												
Dedicated for use in a specific experiment or service of experiments	27%	31%	17%	28%	44%	37%	44%	40%	32%	44%	21%	23%
Available for general purpose use	73%	69%	83%	72%	56%	63%	56%	60%	68%	56%	79%	77%
Mean number of users per system per year												
All in-use systems	14	14	49	46	21	19	9	11	[illegible]	13	24	19
Dedicated	8	8	21	20	18	7	5	6	8	9	12	7
General purpose	16	17	54	57	23	26	12	14	13	15	28	23

[1]See Appendix Tables B-21, B-2 and B-26

SOURCE: National Science Foundation, SRS

3.5 MAINTENANCE AND REPAIR

As has been seen with other indicators, trends in equipment maintenance and repair (M/R) vary for different fields within the cluster of engineering and related fields.

For mechanical engineering, M/R trends were generally unremarkable in that they were very similar to overall trends for all S/E fields (Table 22). The only unusual findings for this field were that the average annual cost for service contracts in 1985-86 was comparatively high ($6,600 per system), and the percentage of in-use systems that received no M/R during that year was also unusually high (43%). These findings are consistent with complaints frequently heard from academic scientists/engineers that service contracts have become prohibitively expensive in recent years.

In computer science, electrical engineering, and the smaller fields of engineering, maintenance/repair expenditures grew at rates far above the overall S/E average. In all three of these field categories, annual expenditures for service contracts more than doubled during the three-year interval covered by this study, leading to the above-average M/R expenditures (Figure 12). In all three of these fields, the proportion of in-use systems receiving no M/R at all increased, but there was no indication (as yet) of any deterioration in the general working condition of the equipment in these fields (Table 22).

As with so many other trend indicators, the M/R findings for materials science were unusual. Despite a slight increase in equipment stocks in this field, annual M/R expenditures actually declined, both in real dollar terms (a 9% decline) and in the index of M/R expenditures as a percent of the aggregate purchase price of all in-use equipment (down from 4.6% to 3.6%). Unit costs for service contracts nearly doubled (from $4,500 to $8,500 per system), but this increase was offset by cutting in half the proportion of systems being maintained with service contracts (from 21% to 10%). According to the administrators of several Materials Research Labs, these trend findings do not represent any formal change in policy regarding use of service contracts. These organizations are large enough to support their own staffs of in-house M/R personnel and are thereby able to achieve comparatively low (and declining) levels of dependency on outside service contracts.

Table 22. Maintenance and repair (M/R) of research equipment in computer science, engineering, and materials science, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields		Computer science		Engineering						Materials science	
					Electrical		Mechanical		All other			
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Annual expenditures for M/R												
Total (dollars in millions)[2]	$50.0	$79.0	$3.1	$7.6	$2 3	$4.3	$1.8	$2.8	$4.3	$49.1	$1.6	$1.6
Percent change from 1982-83[2]		41%		111%		68%		41%		84%		-9%
M/R expenditures as a percent of system purchase price	2 8%	3.7%	6.2%	7.5%	3.5%	3.9%	3.6%	3.9%	3.0%	4.3%	4.6%	3.6%
Annual expenditures for service contracts												
Total (dollars in millions)[2]	$25.7	$48.3	$2.7	$6.9	$1 0	$2.7	$1.0	$1.9	$1.7	$4.0	$0.6	$0.6
Percent change from 1982-83[2]		67%		116%		146%		66%		102%		3%
Annual expenditures for all other forms of M/R												
Total (dollars in millions)[2]	$24.3	$30.7	$0.4	$0 7	$1.3	$1 6	$0.8	$0.9	$2.6	$5 1	$1.0	$1.0
Percent change from 1982-83[2]		12%		68%		8%		8%		68%		16%
Percent of in-use systems with M/R from:												
Service contracts	24%	24%	53%	49%	13%	14%	11%	16%	11%	15%	21%	10%
Other means of service	58%	50%	39%	36%	74%	47%	55%	41%	71%	50%	67%	60%
No M/R was required	18%	26%	8%	15%	13%	39%	34%	43%	18%	35%	[illegible]	30%
Mean annual M/R expenditures per system (dollars in thousands)												
Service contracts	$3.2	$3 9	$6.2	$6 7	$4 9	$8 2	$8.3	$6 6	$4.0	$5.7	$4.5	$8.5
All other means of M/R	$2.5	$2 5	$2.9	$2 5	$3.6	$4.5	$3.5	$4.5	$2.9	$6.6	$7.5	$5.5
General working condition of in-use systems (percent of systems)												
Excellent	52%	55%	56%	45%	54%	54%	53%	55%	49%	54%	32%	40%
Adequate	38%	38%	37%	49%	36%	41%	43%	39%	40%	40%	51%	47%
Insufficient	10%	7%	7%	6%	10%	5%	4%	6%	11%	6%	17%	14%

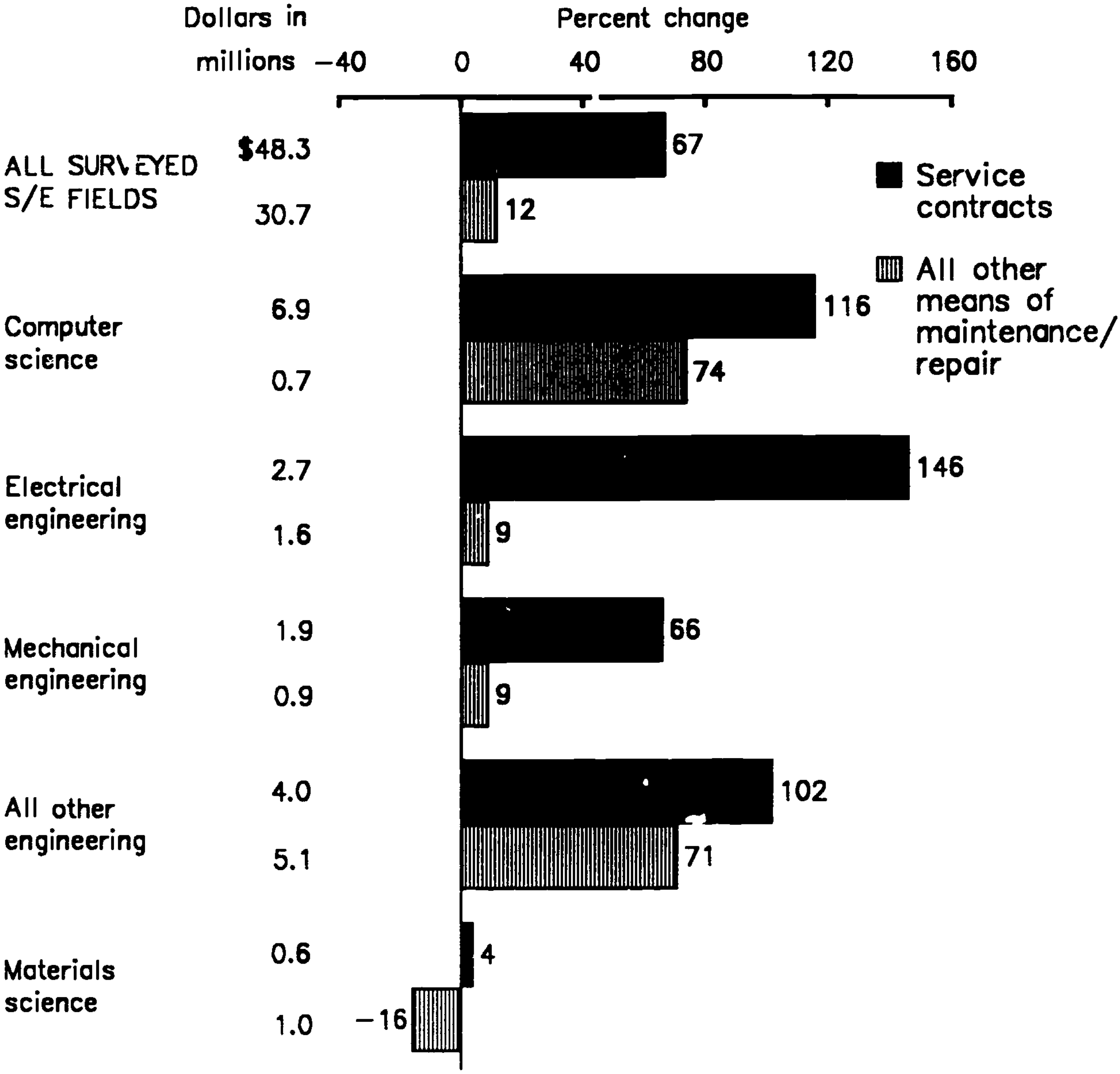
[1]From Appendix Tables B-8, B-17, B-27, B-27a, B-28, B-28a, B-30, and B-30a

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

71

Figure 12
Annual expenditures in 1985–86 for instrumentation maintenance and repair in computer science, engineering, and materials science and percent change from 1982–83



SOURCE. National Science Foundation, SRS

4. TRENDS IN THE BIOLOGICAL AND AGRICULTURAL SCIENCES

This section discusses trend findings for three field-setting groups within the life sciences: the agricultural sciences (where research equipment is found almost exclusively in large, state-operated universities), and two subdivisions within the biological sciences -- biological science equipment in medical schools and biological science equipment in all other academic settings. The medical school data come from what are usually called the "basic science" departments (biochemistry, physiology, etc.), as contrasted to the "clinical" or "medical science" departments (medicine, surgery, pediatrics, etc.), which are not included in this study.

4.1 AMOUNT OF EQUIPMENT

In the three-year interval between the 1982-83 and 1985-86 studies, equipment turnover in the biological and agricultural sciences was somewhat lower than the average for all S/E fields. The agricultural sciences retired from use only 14 percent of the systems in use in 1982-83, as compared with an overall S/E retirement rate of 23 percent during this period (Appendix Table B-6). Also, of the agricultural sciences' 1985-86 stock of in-use equipment, a comparatively small proportion had been acquired in the previous three years: 29 percent, as compared with a 37 percent acquisition rate for all S/E fields. The biological sciences showed similarly low turnover rates from 1982-83 to 1985-86, though they were somewhat closer to the overall S/E average (Appendix Table B-6).

With their lower than average rates of equipment turnover, one might expect the biological and agricultural sciences to have had comparatively little net growth in equipment stocks. However, lower rates of retirement meant that new systems were often additions to the stock rather than replacements, and the overall increase in the number of research instruments was actually above average both for the agricultural sciences (52%) and for the biological sciences (55%) at colleges and universities (Table 23). Biological science units in medical schools showed a somewhat lower net increase (33%).

Instrumentation stocks in the biological and agricultural sciences have grown at higher rates when measured in dollar terms than when change is measured in terms of the number of

Table 23. Instrumentation amounts, prices, and expenditures in the agricultural and biological sciences, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields	Agricultural sciences	Biological sciences	
			Colleges/ universities	Medical schools
Number of systems in research use				
1982-83	36,300	1,600	6,400	8,900
1985-86	53,900	2,600	10,300	12,000
Percent change[2]	43%	52%	55%	33%
Aggregate purchase price of systems in research use (dollars in millions)				
1982-83	$1,311	$38	$166	$254
1985-86	$1,982	$62	$283	$360
Percent change[2]	44%	61%	63%	39%
Mean amount of in-use equipment per institution (dollars in millions)				
1982-83	$5.31	$0.24	$1.07	$2.76
1985-86	$7.45	$0.36	$1.63	$3.92
Percent change[2]	39%	53%	55%	39%
Mean price per system				
1982-83	$36,100	$22,700	$25,900	$28,600
1985-86	$36,800	$24,200	$27,500	$30,000
Percent change[2]	1%	6%	5%	4%
Annual expenditures for research equipment (dollars in millions)				
1982-83	$410	$28	$52	$81
1985-86	$690	$33	$92	$98
Percent change[2]	48%	7%	59%	13%
Annual equipment expenditures as a percent of total R&D expenditures				
1982-83	8%	3%	9%	
1985-86	10%	3%	10%	

[1]From Appendix Tables B-7 to B-10, B-34, and B35.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

systems. The dollar amount of in-use equipment in the agricultural sciences increased by 61 percent (compared to 72% vs. 44% for all S/E fields), and similar rate of growth was seen for biological science instrumentation in academic settings outside medical schools (up 63%). The rate of growth for medical school equipment in the biological sciences was somewhat lower (39%). However, medical schools continued to maintain their prominence within the biological sciences. Medical schools had an average of $3.9 million of in-use research equipment per institution in 1985-86, far above the average for other institutions, $1.6 million. The average increase in biological science equipment stocks over the study's three-year period was $1.1 million per medical school, again far above the analogous figure for the other institutions, $0.6 million (Figure 13).

As had also been the case in 1982-83, the average cost per system in 1985-86 continued to be lower in the agricultural and biological sciences than in any of the other fields encompassed by this research (Appendix Table B-10).

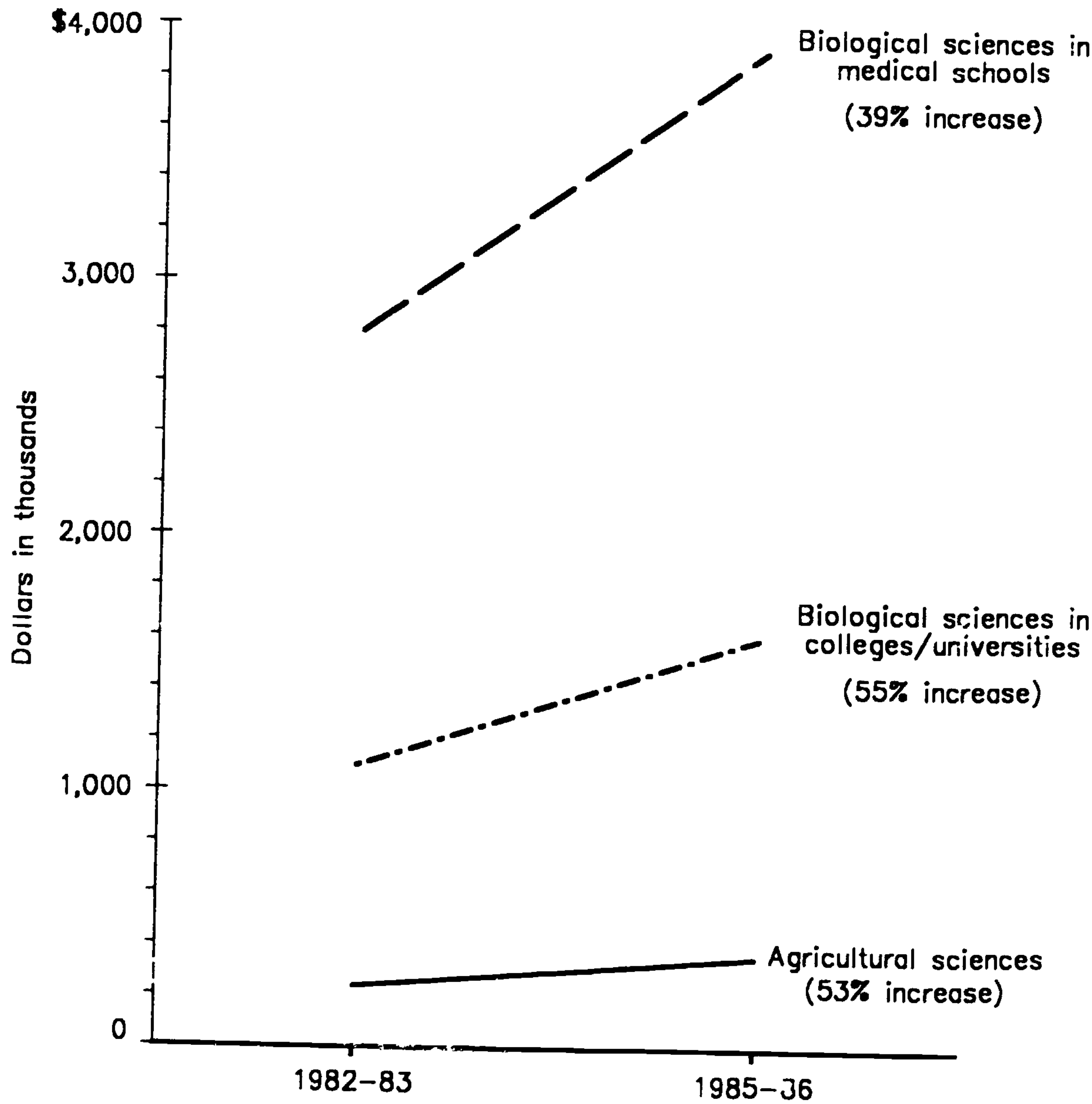
4.2 SOURCES OF FUNDS

The biological sciences at colleges and universities were comparatively successful in attracting increases of Federal funding support for research equipment. In constant dollar terms, Federal funding support increased 47 percent for the biological sciences at colleges and universities and 41 percent at medical schools as compared to 30 percent for all S/E fields combined (Table 24).

The comparative success of the biological sciences in achieving above-average rates of growth in Federal instrumentation support is largely due to the fact that the bulk of their Federal funding (76%) comes from NIH, the agency with the greatest increase in funding during the study period.

In real dollar terms, Federal instrumentation funding in the agricultural sciences increased by a comparatively large 73 percent from 1982-83 to 1985-86, while other sources of equipment funds increased at about the same rates in the agricultural sciences as for all S/E fields combined (e.g., support from institution funds increased by 46% in the agricultural sciences as compared to 47% across all S/E fields). The relative increase in Federal support was not an especially important development, however, since the increase was from a relatively small base:

Figure 13
Mean amount of in-use instrumentation per institution in the agricultural and biological sciences, 1982-83 to 1985-86



SOURCE: National Science Foundation, SRS

Table 24. Sources of funds for purchase of in-use systems in the agricultural and biological sciences, 1982-83 to 1985-86[1]

Source of funds	All surveyed S/E fields		Agricultural sciences		Biological sciences			
					Colleges/ universities		Medical schools	
	1985 amount	Percent change[2]	1985 amount	Percent change[2]	1985- amount	Percent change[2]	1985- amount	Percent change[2]
	(dollars in millions)							
Total, all reported sources	$1,884	42%	$60	58%	$272	62%	$334	37%
All Federal sources	$906	30%	$14	73%	$124	47%	$174	41%
NIH	$270	46%	$2	*	$79	51%	$148	41%
NSF	$306	26%	$4	*	$32	26%	$19	66%
USDA	$7	39%	$4	*	$3	*	$<1	*
All other	$368	34%	$5	*	$11	81%	$7	6%
All non-Federal sources	$978	55%	$46	54%	$147	78%	$159	33%
Institution funds	$580	47%	$27	46%	$99	93%	$110	23%
State government	$114	72%	$12	74%	$24	72%	$14	139%
Business/private donations	$239	69%	$6	*	$19	45%	$29	59%
Other	$45	61%	$1	*	$5	17%	$6	-5%

[1]See Appendix Tables B-13 to B-14a

[2]Estimates are adjusted for inflation. For procedure, see Appendix F

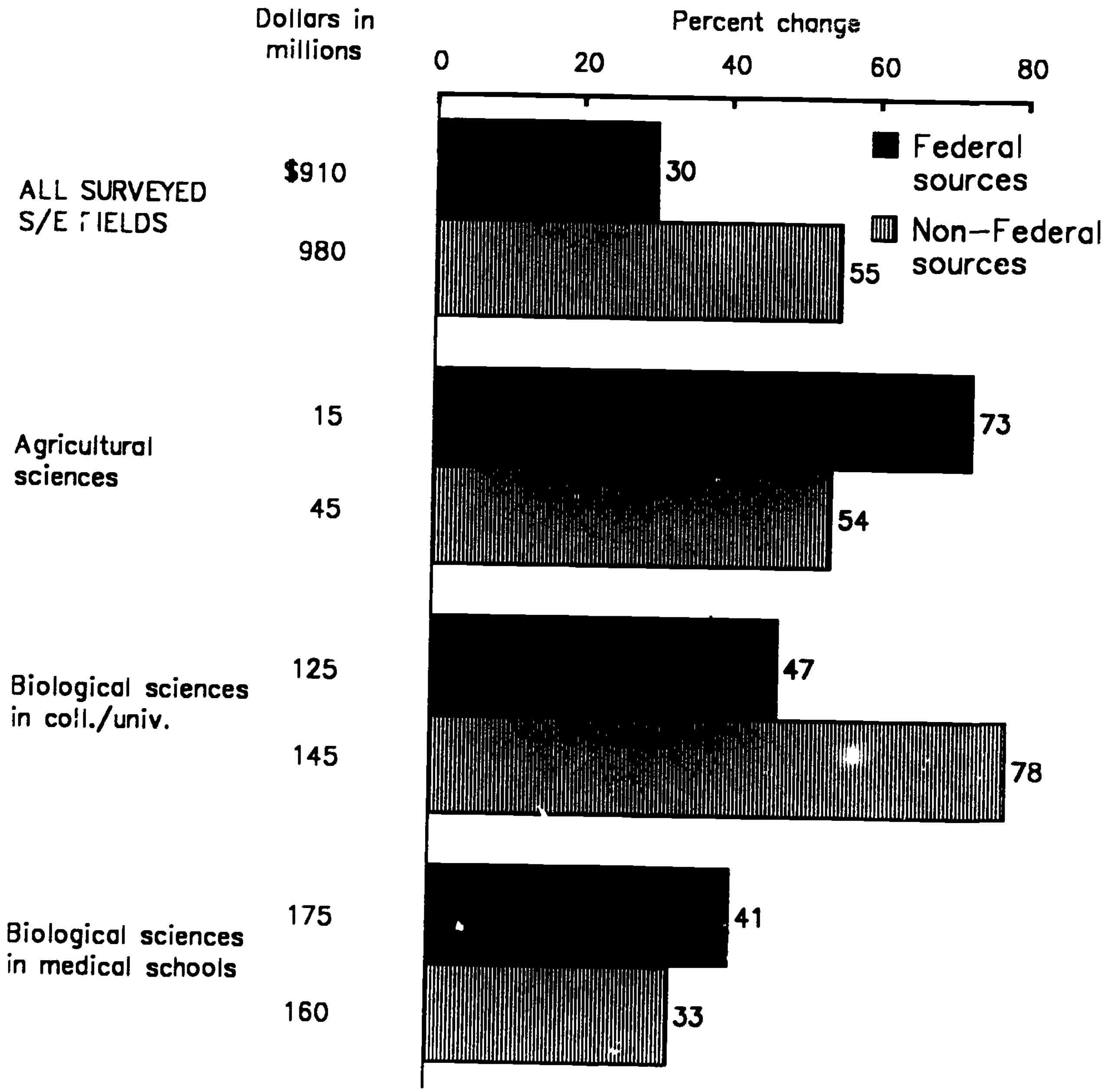
*Unstable percentage: 1982-83 base is less than $4 million.

SOURCE: National Science Foundation, SRS

Federal support accounted for only 22 percent of the dollar amount of in-use research equipment in the agricultural sciences in 1982-83, and it increased only to 24 percent in 1985-86 (Appendix Table B-13a).

The agricultural sciences experienced a 54 percent increase in non-Federal support, essentially the same as the non-Federal increase across all S/E fields (55%) (Figure 14). In the biological sciences, colleges and universities had an above average increase in non-Federal support (78%), and medical schools had a below average increase (33%).

Figure 14
Aggregate purchase price of in-use research equipment in 1985-86 in the agricultural and biological sciences, by source of funds, and percent change from 1982-83



SOURCE: National Science Foundation, SRS

4.3 QUALITY/ADEQUACY

Equipment Quality

For the biological sciences, both in medical schools and in other academic settings, a substantial upward shift occurred in the quality of available research equipment over the period 1982-83 to 1985-86. The greatest rate of inventory growth was in the real dollar amount of equipment currently under construction/development (up more than 200% for both colleges/universities and medical schools), and the smallest growth rate was for inactive or inoperable equipment (up 22% and 16%, respectively) (Table 25). Among systems in actual research use, those with state-of-the-art capabilities grew at a faster rate than ones without such capabilities (67% vs. 62% for colleges and universities, and 47% vs. 35% for medical schools). Overall, advanced systems increased at substantially higher rates than other systems in both biological science subcategories (Figure 15).

Table 25. Composition of research equipment inventories in the agricultural and biological sciences, 1982-83 to 1985-86[1]

Inventory component	All surveyed S/E fields		Agricultural sciences		Biological sciences			
					Colleges/ universities		Medical schools	
	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]	1985-86 amount	Percent change[2]
	(dollars in millions)							
Total, all systems	$2,342	38%	$67	54%	$313	62%	$402	38%
Advanced systems	$677	56%	$18	49%	$98	76%	$120	53%
Not yet in use	$82	136%	$1	*%	$9	*%	$9	*%
State-of-the-art	$595	50%	$18	49%	$89	67%	$115	47%
Other systems	$1,666	32%	$50	56%	$216	57%	$260	32%
Other in-use	$1,387	41%	$45	66%	$195	62%	$245	35%
Inactive/inoperable	$279	1%	$5	-02%	$21	22%	$33	16%

[1]See Appendix Tables B-4, B-4a.

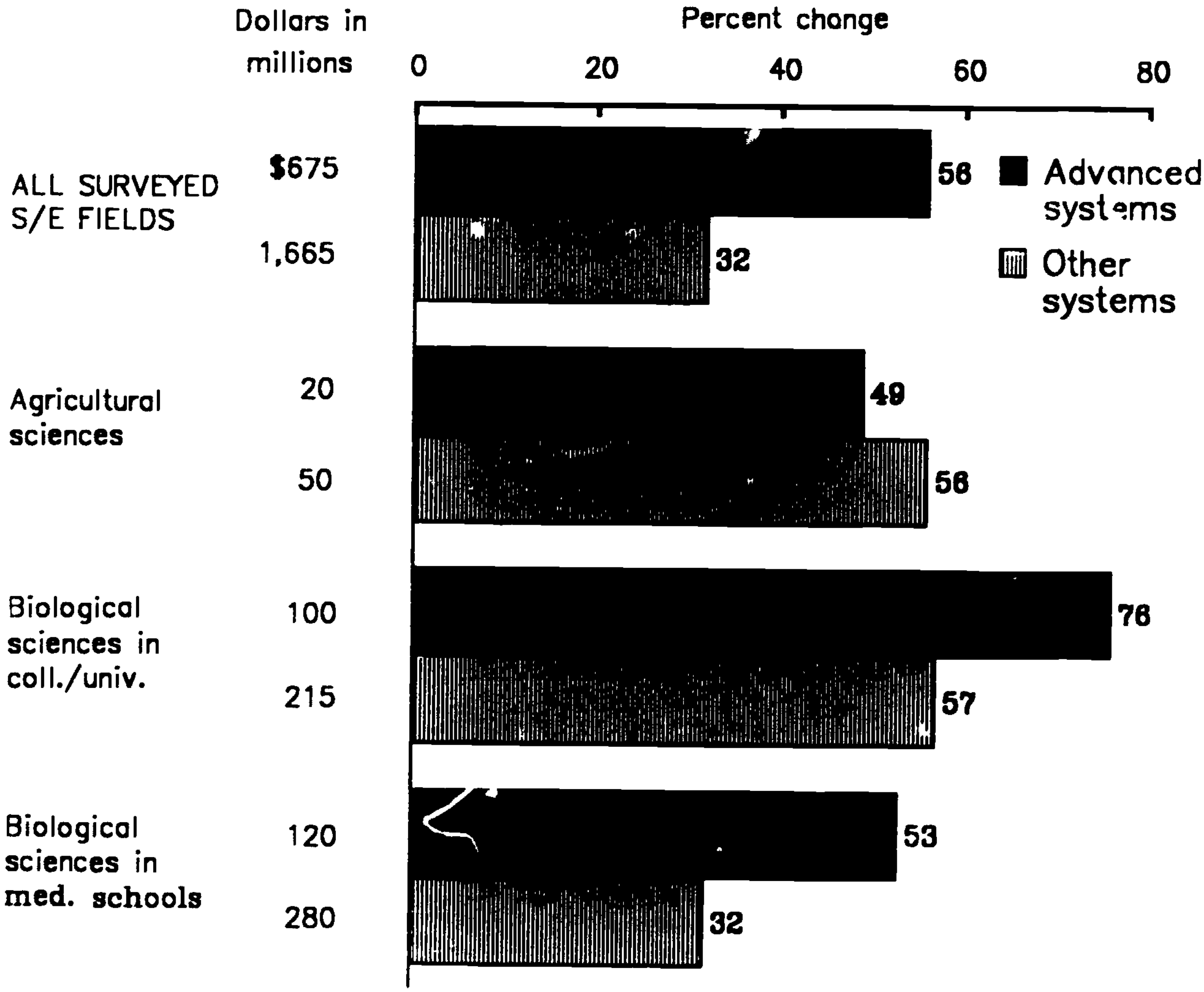
[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

*Unstable percentage: 1982-83 base is less than $6 million.

SOURCE: National Science Foundation, SRS

73

Figure 15
Aggregate purchase price of the 1985–86 stock of research equipment in the agricultural and biological sciences, by system status,[1] and percent change from 1982–83



[1] Advanced systems include ones that are still under development and not yet in use, plus in–use systems that are judged by their users to be state–of–the–art. Other systems include in–use systems that are not state–of–the–art, plus inactive/inoperable systems.

SOURCE: National Science Foundation, SRS

In the agricultural sciences, no such qualitative shift was in evidence. There, similar rates of growth were seen for not-yet-in-use equipment (50%), state-of-the-art equipment (49%), and other in-use equipment (66%). The proportion of the inventory (by dollar value) that consists of advanced systems is slightly below average at 27 percent, and has remained stable since 1982-83.

Adequacy of Existing Research Equipment

Department heads' assessments of the general adequacy of available research equipment did not change a great deal in the biological or agricultural sciences. In 1982-83, biological science department heads in medical school settings were generally satisfied with available research equipment: only 16 percent indicated dissatisfaction by characterizing their equipment as insufficient (Table 26). This "dissatisfaction index" for biological science department heads in non-medical school settings was higher (36%), exactly the same as the overall average across all S/E fields. By 1985-86, the two groups had converged somewhat, with the dissatisfaction

Table 26. Adequacy of research equipment in the agricultural and biological sciences, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields		Agricultural sciences		Biological sciences			
					Colleges/ universities		Medical schools	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Percent of non-state-of-the-art systems whose users also have access to more advanced systems when needed	54%	62%	44%	57%	56%	63%	58%	65%
Percent of department heads assessing the overall adequacy of the research equipment available to their faculty as:								
Excellent	11%	11%	8%	6%	13%	14%	16%	11%
Adequate	54%	54%	46%	50%	52%	53%	68%	66%
Insufficient	36%	35%	46%	45%	36%	32%	16%	24%

[1]See Appendix Tables B-20 and B-31.

SOURCE: National Science Foundation, SRS

level going up to 24 percent for medical school biological science department heads and going down to 32 percent for biological science department heads outside medical schools. In the agricultural sciences, the equipment dissatisfaction index was a comparatively high 46 percent in 1982-83 and was essentially the same (45%) in 1985-86.

4.4 USAGE PATTERNS

In the biological sciences, the average numbers of users per system per year were somewhat lower than for most other S/E fields, and the averages did not change much from 1982-83 to 1985-86. Thus, across all S/E fields, the average number of users was 14.2, while the respective numbers of users of biological sciences equipment in medical schools and in colleges and universities were 11.2 and 12.0 (Table 27). The agricultural sciences also showed little change in average number of users per system per year (from 11.0 to 10.8).

Table 27. Patterns of equipment usage in the agricultural and biological sciences, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields		Agricultural sciences		Biological sciences: Colleges/ universities		Biological sciences: Medical schools	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Percent of in-use systems located in:								
Within-department labs of individual principal investigators (PI's)	59%	56%	64%	56%	65%	62%	64%	61%
Department-managed common labs	32%	31%	31%	37%	30%	30%	32%	30%
Other shared-access locations	8%	13%	6%	7%	5%	8%	5%	9%
Percent of in-use systems that are:								
Dedicated for use in a specific experiment or series of experiments	27%	31%	24%	23%	14%	15%	19%	22%
Available for general purpose use	73%	69%	76%	77%	86%	85%	81%	78%
Mean number of users per system per year								
All in-use systems	14	14	11	11	12	12	11	11
Dedicated	8	8	7	8	8	7	7	6
General purpose	16	17	12	11	13	13	12	13

[1]See Appendix Tables B-21, B-24, and B-26.

SOURCE: National Science Foundation, SRS

Equipment in the agricultural and biological sciences was less likely to be dedicated for use in a specific experiment than overall S/E equipment. In the agricultural sciences, 23 percent of the in-use systems were dedicated, compared with 31 percent overall. In the biological sciences, 22 percent of the systems in medical schools were dedicated, as were 15 percent at colleges and universities.

The most common location for equipment in the agricultural and biological sciences was in within-department labs of individual principal investigators (PI's), though the proportion in such labs declined slightly in each area (as was true across all S/E fields). The greatest drop was for the agricultural sciences, where 64 percent had been within such labs in 1982-83, and 56 percent were in 1985-86. Changes in the biological sciences were smaller, from 65 percent to 62 percent at colleges and universities, and from 64 percent to 61 percent at medical schools.

4.5 MAINTENANCE AND REPAIR

The agricultural sciences had a comparatively small increase in total maintenance/repair expenditures (12%), based on an 11 percent increase in expenditures for service contracts and a 17 percent increase in other servicing costs (Table 28). These findings were in contrast to the general trends across all S/E fields, where there were large increases in service contract expenditures (67%) and the majority of 1985-86 maintenance/repair expenditures were devoted to service contracts (61% overall, compared with 47% in agriculture).

In the biological sciences, some interesting differences emerged both in the level and in the composition of maintenance/repair costs. Medical school biological science programs had a below average increase of 17 percent in overall maintenance/repair expenditures, consisting of a relatively small (22%) increase in expenditures for service contracts and no constant dollar increase in other servicing costs. By contrast, biological science departments outside medical schools evidenced a larger than average increase in expenditures: overall (58%), for service contracts (69%), and also for other means (30%) (Figure 16). Biological science equipment in both types of settings had larger than average portions of maintenance/repair expenditures for service contracts, with proportions of 80 percent for medical schools and 77 percent for colleges and universities. (These were increases from 77% and 71%, respectively, in 1982-83).

The above variations in the amount and the type of servicing costs are not related to users' evaluations of the general working condition of their in-use systems. Roughly equivalent percentages of equipment were rated as excellent, adequate, or poor, regardless of whether the users were in the agricultural sciences or in either setting within the biological sciences.

Table 28. Maintenance and repair (M/R) of research equipment in the agricultural and biological sciences, 1982-83 to 1985-86[1]

Index	All surveyed S/E fields		Agricultural sciences		Biological sciences			
					Colleges/ universities		Medical schools	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Annual expenditures for M/R								
Total (dollars in millions)	$50.0	$79.0	$1.4	$1.7	$5.9	$10.4	$10.1	$12.8
Percent change from 1982-83[2]		41%		12%		58%		17%
M/R expenditures as a percent of system purchase price	3.8%	3.7%	3.7%	2.7%	3.5%	3.7%	4.0%	3.5%
Annual expenditures for service contracts								
Total (dollars in millions)	$25.7	$48.3	$0.6	$0.6	$4.2	$7.9	$7.8	$10.2
Percent change from 1982-83[2]		67%		11%		69%		22%
Annual expenditures for all other forms of M/R								
Total (dollars in millions)	$24.3	$30.7	$0.7	$0.9	$1.7	$2.4	$2.3	$2.5
Percent change from 1982-83[2]		12%		17%		30%		0%
Percent of in-use systems with M/R from:								
Service contracts	24%	24%	23%	17%	37%	35%	39%	37%
Other means of service	58%	[illegible]	55%	61%	46%	45%	43%	41%
No M/R was required	18%	[illegible]	22%	22%	17%	20%	17%	22%
Mean annual M/R expenditures per system (dollars in thousands)								
Service contracts	$3.2	$3.9	$1.7	$1.9	$1.9	$2.4	$2.4	$2.5
All other means of M/R	$2.5	$2.5	$1.6	$1.2	$1.2	$1.1	$1.2	$1.2
General working condition of in-use systems (percent of systems)								
Excellent	52%	55%	56%	54%	[illegible]	54%	52%	57%
Adequate	38%	38%	37%	40%	[illegible]	37%	39%	36%
Poor	10%	7%	7%	6%	6%	8%	9%	7%

[1] From Appendix Tables B-8, B-17, B-27, B-28, B-28a, B-30, B-30a.

[2] Estimates are adjusted for inflation. For procedure, see Appendix F

SOURCE: National Science Foundation, SRS

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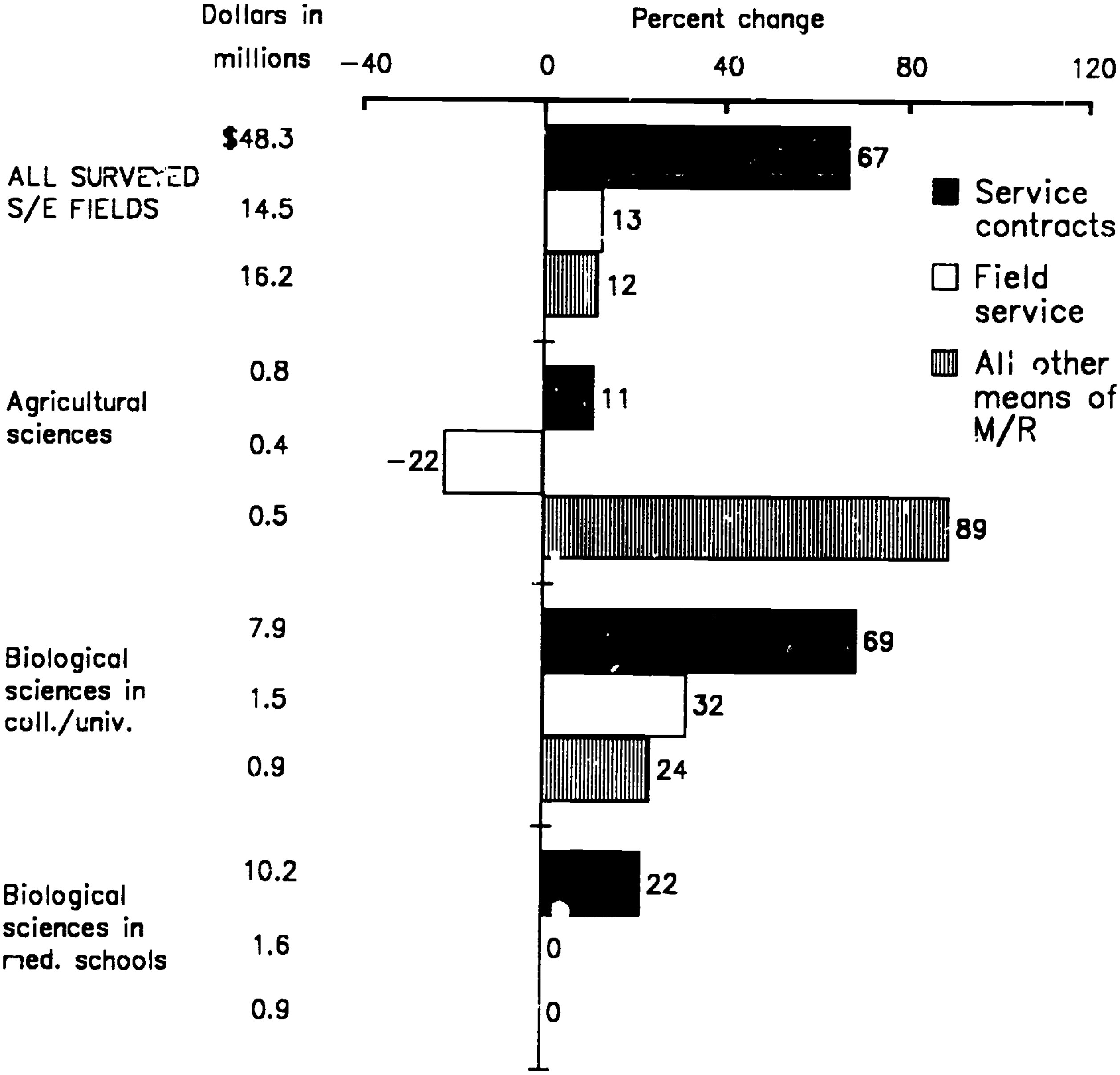
Figure 16
Expenditures for maintenance/repair (M/R) of in-use equipment in the agricultural and biological sciences in 1985-86, by type of M/R, and percent change from 1982-83



SOURCE: National Science Foundation, SRS

APPENDIX A

TECHNICAL NOTES

TECHNICAL NOTES

SAMPLE DESIGN

The following sections briefly describe the sample designs used in the 1982-83 baseline instrumentation study and in the 1985-86 update study. Additional information is presented in a detailed report, which is available upon request from the National Science Foundation.[1]

Institutions. In the baseline study, data were collected from: (a) a stratified probability sample of 43 institutions selected from the "universe" of nonmedical, nonmilitary U.S. colleges and universities that had $3 million or more in separately-budgeted science and engineering (S/E) R&D expenditures in any of the Fiscal Years 1977 to 1980, excluding university-administered Federally-funded R&D Centers (FFRDC's),[2] and (b) a separately selected probability sample of 24 medical schools from the universe of 92 medical schools with annual NIH research grants and contracts of $3 million or more in FY 1982. The 157 institutions represented in the first (nonmedical) component of the sample collectively accounted for 95 percent of all nonmedical, non-FFRDC R&D expenditures reported to NSF for FY 1980 by all U.S. colleges and universities. Thus, although the survey represented only a small fraction of the nation's approximately 3,000 postsecondary institutions, it encompassed most institutions with significant capabilities for the kinds of advanced research that require instrumentation costing $10,000 or more.

In selecting the baseline study sample of 43 colleges/universities, the probability of selection of each institution in the survey universe was approximately proportionate to its R&D size, as indicated by it FY 1980 nonmedical, S/E R&D expenditures. Within R&D size strata, the proportion of private (or public) institutions in the sample was approximately the same as in the nation as a whole.

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[1] Sample Design Report: 1985-86 NSF National Survey of Academic Research Instruments and Instrumentation Needs. National Science Foundation (SRS), December 1987

[2] Academic Science R&D Funds, Fiscal Year 1980: Detailed Statistical Tables Surveys of Science Resources Series, National Science Foundation (GPO Publication No. NSF83-200), 1982.

The college/university component of the update survey sample was expanded and updated to represent current patterns of S/E R&D spending, as reporting in the most recent NSF R&D expenditures study.[3] Using the same eligibility criteria that had been applied in the baseline instrumentation study (i.e., at least $3 million in nonmedical R&D in any of the years FY 1981 - FY 1984), the update study college/university universe was found to consist of 174 institutions. Stratified probability sampling procedures were again used to select an update study sample of 55 colleges and universities: the 43 original institutions plus an additional 12 that had not been sampled in the baseline study. The sample of 24 medical schools for the update survey was exactly the same as for the baseline study.

Departments. In the 1982-83 baseline study, all institution-operated academic departments and nondepartmental research/instrumentation installations in engineering and in the agricultural, biological, computer, environmental, and physical sciences were identified and asked to participate in the survey.[4] Excepted from this sample were: (a) departments that contained no research instrument systems in the $10,000 to $1 million cost range, (b) general purpose university computer centers, and (c) other nondepartmental installations that, in effect, consisted of a single system costing over $1 million (research reactors, cyclotrons, observatories, etc.). A total of 971 "in-scope" departments were identified, each of which was asked to participate in the baseline study.

The same rules as described above were used to define departments that were "in-scope" for the 1985-86 update survey. To minimize response burden, some sampling of departments in engineering and in the agricultural and biological sciences was done in the update survey. In the computer, environmental, and physical sciences, all "in-scope" departments were asked to participate. The update study sample design for engineering called for a 100 percent sample of: (1) departments at universities that contained fewer than 5 engineering departments; (2) new engineering departments at baseline study institutions, i.e., departments that were not present during the baseline study; and (3) engineering departments that contained 30 or more items of research equipment in the $10,000 - $1 million range. For the remaining departments, the design called for a simple random sample of 50 percent of those containing 15-29 in-scope items of

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[3] Academic Science/Engineering: R&D Funds, Fiscal Year 1984, Detailed Statistical Tables National Science Foundation, 1985.

[4] The term "departments" is used to denote both in-scope research departments and in-scope nondepartmental research/instrumentation installations.

equipment and of 33-1/3 percent of those with 1-14 items. This design resulted in the selection of 212 engineering departments, about the same number that participated in the baseline study (i.e., 220).

Similar designs were used for sampling departments in the agricultural sciences and the biological sciences at colleges and universities (no subsampling was done of biological science departments at medical schools). Altogether, a total of 1,050 departments were sampled for participation in the update survey.

Instruments. The baseline and update surveys both sought to represent all instrument systems that: (a) were used or intended primarily for research during the prior year, and (b) originally cost $10,000 to $1 million including the cost of any separately-purchased, dedicated accessories or components.

In the baseline study, the sequence of steps at each department was as follows: First, a preliminary listing of all items of research equipment costing $10,000 or more was obtained, usually from the university's computerized central property inventory system. The preliminary lists often contained, in addition to items of research equipment, miscellaneous property such as furniture, physical plant equipment (e.g., trucks, heating and air conditioning units), secretarial equipment (e.g., word processors), and the like. After screening out clearly inappropriate entries, the contractor selected a random sample of equipment items in each department and facility. The instrument sample design included all items costing $100,000 to $999,999, and items in the $50,000 to $99,999 range were sampled at higher rates than items in the $10,000 to $49,999 range. In the category under $50,000, sampling rates ranged from 100 percent for departments/facilities with fewer than 10 such items down to 12.5 percent (1/8) for departments/facilities with more than 100 items in this cost range. The intent of this design was to ensure adequate sample sizes for analysis without overburdening large departments and facilities.

Across the baseline institutions, a total of 12,691 equipment items were identified in preliminary listings, and 4,648 were selected to be in the baseline survey sample -- 100 percent of the items costing $100,000 - $999,999; 85 percent of all items costing $50,000 - $99,999; and 29 percent of those in the $10,000 - $49,999 range.

At the 12 new institutions in the update study, the instrument sample design and sampling procedures were essentially the same as in the baseline study -- listings of all items costing $10,000 or more were obtained for sampled departments, and instrument samples were selected within the same cost range categories as had been used in the baseline study.

At the 43 colleges/universities and 24 medical schools that had participated in the baseline study, two distinct sets of instruments were involved. At sampled departments, all instruments that had been sampled in the baseline study and had been found to be "in-scope" at that time, were included in the update study. Also included was a second sample of instruments that had been acquired since the earlier study. To obtain this latter sample, baseline study institutions were asked to provide listings only of equipment costing $10,000 or more that had been obtained since the earlier study, and instrument samples were selected from these listings of new acquisitions.

Altogether, the update study sample contained 14,424 instruments. About half of these (7,364) had also been surveyed in the baseline study. The rest were either new acquisitions at baseline study institutions or instruments sampled from the 12 new institutions.

SURVEY PROCEDURES AND RESPONSE

Survey Administration. Survey procedures were essentially the same for the baseline and update studies At each institution, all data collection arrangements were handled by a survey coordinator appointed by the office of the president of the college/university or medical school. Typically, coordinators were themselves senior administrators, such as Dean of the Graduate School or Vice President for Research. These individuals were responsible for: identifying all relevant departments and facilities; obtaining needed preliminary lists of equipment; and, after equipment samples had been selected by the survey contractor, arranging for the distribution, completion, and return of survey questionnaires.

Each sampled department or facility was sent a packet containing a cover letter, a Department/Facility Questionnaire (Appendix C), and Instrument Data Sheets for each sampled item of research equipment. There were two versions of the Instrument Data Sheet in the update study, one for updating of information about an item that had been sampled in the baseline study

(Appendix D), and one for use with equipment items that had not been surveyed in the baseline study (Appendix E). The latter Data Sheet was essentially the same as the one used in the baseline study.

Survey Response. The baseline study had exceptionally high response rates. All 67 sampled colleges/universities and medical schools (100%) agreed to participate in the study, and the response rates for the Department/Facility Questionnaire and Instrument Data Sheet were 94 percent and 97 percent, respectively.

The response rates in the 1985-86 update study were also high. All 67 of the baseline study institutions agreed to continue participating in the update study, and all 12 of the supplemental institutions also agreed to participate. Thus, at the institution level, the response rate was again 100 percent. Completed Department/Facility Questionnaires were received for 961 of the 1,050 sampled departments (92%).

At the instrument level, update study responses were received for 13,503 of the 14,424 sampled items (94%). Of the remaining items, only 108 were outright refusals to provide the requested information (0.8%). The rest were nonresponses due to the absence of the cognizant faculty investigator, the inability of the department to locate the sampled item, or other such problems. Of the 13,503 responses, 11,271 were determined to be legitimate ("in-scope") items of research equipment meeting all of the study's definitional requirements (83%). The rest were determined to be out-of-scope for the update survey: because the item no longer existed, having been cannibalized, traded-in, or junked (N=1,297); because it was not (or was no longer) a research instrument (N=541); or because it was ineligible for other reasons -- cost, age, etc. (N=394).

Of the 11,271 in-scope research instruments in the data base, 9,583 (85%) had actually been used for research during the applicable survey year, 250 (3%) were still under construction/development and not yet in research use at the end of the survey year, and the remaining 1,438 (15%) were physically present but completely inactive or inoperable throughout the applicable survey year. These latter instruments are considered part of the total national stock of research equipment, though they are for the most part obsolete, mechanically and/or technologically.

Estimation Procedures. All results in this report are in the form of national estimates, statistically weighted to represent all S/E research departments and nondepartmental research units at the institution universe described above.

The estimation weights applied to Department/Facility Questionnaire data are the product of three terms:

- The university selection weight: the inverse of the particular university's probability of selection;
- The department/facility weight: the inverse of the particular department's probability of selection (in the baseline study, all department weights are 1.0; in the update study, some departments have weights greater than 1.0); and
- A nonresponse adjustment obtained by dividing the number of originally sampled departments by the number actually responding to the survey. These nonresponse weights were calculated separately within each cell defined by cross-classification of institution control (private vs. public), R&D size (top 20 in R&D expenditures vs. not in the top 20), type (college/university vs. medical school), and major field (engineering, physical science, computer science, agricultural sciences, biological sciences, environmental science, or other, n.e.c.).

Estimation weights for the survey of $10,000 to $1 million instruments were somewhat more complex. The weight for a completed instrument questionnaire was the product of:

- The university sampling weight -- the inverse of the university's probability of selection;
- The department sampling weight -- the inverse of the department's probability of selection;
- The instrument sampling weight -- the inverse of the probability of selection of the particular instrument from the department equipment list; and
- A nonresponse adjustment, calculated (as for the Department/Facility Questionnaire) within cells defined by the cross-classification of institution control, R&D size and type, major field, instrument status (update, new), and instrument cost ($10,000 - $49,000; $50,000 - $74,999; $75,000 - $999,999).

Information about the statistical precision of national estimates derived from the study samples of departments and instruments is presented in Appendix G.

Most analysis variables, whether obtained from the Department Questionnaire or from the Instrument Data Sheet, had no more than 1 or 2 percent nonresponse. Because item nonresponse was inconsequential, most tabulations in this report simply exclude cases with missing values on any of the table's variables. This procedure has no effect on estimates of percentages, means, or other ratios. For estimates of totals (e.g., estimated total number of instruments in the national stock or estimated total cost of this equipment), the effect is to lower estimates slightly and to create slight differences when two or more tables present estimates of the same total. The reader is alerted to expect slight, inconsequential discrepancies of this kind when comparing findings from one table to another.

DEFINITIONS

The following definitions and guidelines are provided to aid in the effective use of the data in this report.

Survey Year. The reference survey year for research equipment in Phase I fields (i.e., the physical, computer, and materials sciences and engineering) of the baseline study was the 1982 calendar year. For Phase I of the update study, the survey year was 1985. The survey year for Phase II fields (i.e., the agricultural, biological, and environmental sciences) was 1983 in the baseline study and 1986 in the update study. In both studies, actual data collection occurred shortly after the start of the year following the applicable survey year.

Field of Science/Engineering. Field classifications for in-use research instruments are based on user descriptions of the instrument's principal field of research use. Field classifications for department-level data and for instrument systems that were not used for research in a given survey year indicate the principal field of research in the department.

In its most detailed form, the field typology is as follows:

Engineering

Electrical (electronic, computer engineering)
Mechanical
Metallurgical/materials (ceramic, mining, mineral)
Chemical
Civil (architectural)
Other (e.g., aerospace, agricultural, biomedical, industrial, nuclear, systems)

Agricultural Sciences

Agronomic sciences (e.g., agronomy, horticulture, pomology, plant pathology, soil management)
Animal sciences (e.g., dairy sciences, poultry sciences, animal nutrition, range sciences)
Natural resources management (forestry, pulp and paper production, fisheries and wildlife management, agricultural chemistry)

Biological Sciences

In colleges/universities
In medical schools

Computer Science (no subdivisions)

Environmental Sciences (geological, atmospheric, and oceanographic sciences)

Materials Sciences (interdisciplinary, not just materials engineering)

Physical Sciences

Chemistry (physical, inorganic, polymer; not biochemistry)
Physics and astronomy

Interdisciplinary, n.e.c. (e.g., interdisciplinary nuclear science research facility, textile sciences department)

R&D Size. In the baseline study, this measure was based on institutions' reported FY 1980 total R&D expenditures in all science and engineering fields to be surveyed in Phases I and II. The top 20 institutions, which collectively accounted for about 40 percent of all academic R&D expenditures in applicable fields, were distinguished from the remaining institutions in the survey universe, each of which had R&D expenditures of at least $3 million in FY 1980 or in at least one of the three prior years. The update study used the same definition, based upon NSF R&D expenditures data for FY 1984 and the prior three years. Nineteen of the top 20 institutions in the update study classification had also been in the top 20 in the baseline study classification. In the data analysis, the R&D size variable is used only for colleges/universities. Medical schools are not subdivided in this way.

System. In data collection terms, an instrument system consists of a reference instrument or component selected from a department property list, plus any separately acquired "add-ons" or components that, as of December 31 of the survey year, were dedicated solely for use with the reference item. The instrument system is the basic unit of reference in the equipment survey, and all reported price/cost figures reflect prices/costs for the full system -- the base unit plus all dedicated accessories. The survey is limited to systems with an original purchase price of $10,000 to $1 million.

National Stock. In this report, the term "national stock" of academic research equipment refers to all instrument systems costing $10,000 to $1 million that, as of December 31 of the survey year, were physically located at an academic institution in the survey universe and were used (or intended for use) in original scientific research in one or more of the fields encompassed by the survey. In addition to systems actually used for research in the survey year, this includes existing components of nonoperational systems still under construction at the end of the year and research systems that were inoperable or inactive throughout the year.

Purchase Price. The purchase price refers to the total system purchase price at the time of original purchase (i.e., when new). For multi-component systems, the purchase price is the aggregate price of all components and accessories. Except where clearly specified otherwise, all cost/value/investment statistics in this report refer to system purchase price. In situations where there is a difference between the manufacturer's list price and the (discounted) price actually paid when the instrument was first purchased, the actual price is used in this report.

APPENDIX B

DETAILED STATISTICAL TABLES

LIST OF DETAILED STATISTICAL TABLES

PART I. THE INSTRUMENT SURVEY

THE NATIONAL STOCK OF ACADEMIC RESEARCH EQUIPMENT INCLUDING LARGE AND OBSOLETE SYSTEMS

AMOUNT OF IN-USE EQUIPMENT

LIST OF DETAILED STATISTICAL TABLES (Continued)

MEANS AND SOURCES OF FUNDS FOR ACQUISITION

LIST OF DETAILED STATISTICAL TABLES (Continued)

AGE AND CONDITION

LOCATION AND USAGE

LIST OF DETAILED STATISTICAL TABLES (Continued)

MAINTENANCE AND REPAIR

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PART II. THE DEPARTMENT SURVEY

NEEDS AND PRIORITIES

ANNUAL EXPENDITURES

Table B-1. Trends in the aggregate purchase price of academic research equipment, including systems costing $1,000,000 or more, by equipment category and institution type: National estimates, 1982-83 to 1985-86[1]

Equipment category and institution type	Aggregate purchase price (dollars in millions)			
	1982 -83	1985-86		Percent change[2]
		Unadjusted	Adjusted[2]	
Total	$2,303	$3,441	$3,307	44%
EQUIPMENT CATEGORY				
Systems costing $10,000 - $1,000,000	1,605	2,342	2,221	38
Large systems (generally over $1,000,000), total	698	1,099	1,086	56
General purpose research computer centers	420	799	791	88
Dedicated research computers	3	29	27	861
Research vessels	17	27	27	56
High energy physics systems	164	165	165	0
Observatories	38	13	13	-65
Other large systems	55	66	63	14
INSTITUTION TYPE				
Colleges/universities	2,013	3,028	2,903	44
Private	694	913	872	26
Public	1,319	2,116	2,031	54
Top 20 in R&D	749	960	937	25
Not in top 20	1,264	2,068	1,966	56
Medical schools	290	413	403	39

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Table B-2. Trends in the number of systems in the national stock, by field and institution type: National estimates, 1982-83 to 1985-86[1]

Field and institution type	Number of systems			
	1982-83	1985-86		Percent change[2]
		Unadjusted	Adjusted[2]	
Total	46,500	64,700	62,200	34%
FIELD				
Engineering	9,400	11,900	11,300	20
Chemical	800	1,200	1,200	39
Civil	700	1,200	1,200	**
Electrical	2,200	3,100	2,900	31
Mechanical	1,900	2,400	2,200	21
Metallurgical/materials	1,200	1,300	1,200	-4
Other, n.e.c.	2,500	2,800	2,600	2
Agricultural sciences	2,000	2,900	2,800	45
Agronomic sciences	1,200	1,900	1,800	48
Animal sciences	500	500	500	**
Natural resources management	200	500	500	**
Biological sciences	17,800	24,900	24,300	36
In medical schools	10,500	13,500	13,300	27
In colleges/universities	7,300	11,400	11,000	51
Computer science	1,100	2,300	2,200	98
Environmental sciences	2,700	4,200	4,000	51
Materials science	700	900	900	**
Physical sciences	11,600	15,300	14,500	25
Chemistry	6,400	8,400	7,900	24
Physics/astronomy	5,200	7,000	6,600	27
Interdisciplinary, n.e.c.	1,300	2,300	2,100	65
INSTITUTION TYPE				
Colleges/universities	35,900	51,100	48,700	36
Private	11,900	14,700	14,000	17
Public	24,000	36,500	34,800	45
Top 20 in R&D	12,800	17,500	17,200	35
Not in top 20	23,200	33,600	31,500	36
Medical schools	10,600	13,600	13,400	26

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

**Unstable estimate: 1982-83 base is less than 750 systems.

SOURCE: National Science Foundation, SRS

Table B-3. Distribution of systems in the national stock, by system research status, field, and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	System research status (percent of systems)							
		Not yet in use		In research use				Inactive/ Inoperable	
				State-of-the-art		Other			
		1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total	100%	2%	2%	18%	21%	62%	62%	19%	15%
FIELD									
Engineering	100	4	2	18	19	56	59	23	20
Chemical	100	1	2	16	20	65	61	19	17
Civil	100	**	2	**	20	**	59	**	19
Electrical	100	1	2	19	19	54	62	26	17
Mechanical	100	5	5	19	22	53	52	23	22
Metallurgical/materials	100	2	3	15	21	73	68	10	8
Other, n.e.c.	100	3	1	22	14	50	53	26	28
Agricultural sciences	100	1	1	22	21	62	68	14	10
Agronomic sciences	100	1	1	24	22	61	68	14	9
Animal sciences	100	**	**	**	**	**	**	**	**
Natural resources management	100	**	**	**	**	**	**	**	**
Biological sciences	100	1	1	19	22	69	68	12	9
In medical schools	100	1	1	18	22	69	67	12	10
In colleges/universities	100	*	1	20	22	69	68	11	9
Computer science	100	6	2	17	19	63	74	15	4
Environmental sciences	100	2	3	20	22	61	56	18	19
Materials science	100	**	2	**	16	**	76	**	6
Physical sciences	100	1	2	15	19	61	61	22	18
Chemistry	100	1	1	14	20	63	64	22	15
Physics/astronomy	100	1	3	16	19	60	57	22	21
Interdisciplinary, n.e.c	100	2	7	7	26	8	25	84	42
INSTITUTION TYPE									
Colleges/universities	100	2	2	17	21	60	61	21	16
Private	100	2	2	19	23	57	59	22	16
Public	100	2	2	17	20	62	62	20	16
Top 20 in R&D	100	2	2	15	19	64	64	19	15
Not in top 20	100	2	2	18	21	58	60	22	17
Medical schools	100	1	1	18	22	68	67	12	10

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

*Less than 0.5%

**Unstable estimate: base is less than 750 systems.

SOURCE: National Science Foundation, SRS

Table B-4. Aggregate purchase price of systems in the national stock, by system research status, field, and institution type: National estimates, 1985-86 and percent change from 1982-83[1]

Field and institution type	System research status (aggregate purchase price; dollars in millions)									
	Total		Not yet in use		In research use				Inactive/ Inoperable	
					State-of-the-art		Other			
	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]
Total	$2,342.2	38%	$82.1	136%	$594.8	50%	$1,386.8	41%	$278.5	1%
FIELD										
Engineering	460.9	32	20.8	55	103.5	28	268.3	36	68.4	18
Chemical	40.2	41	0.8	**	9.9	31	22.9	40	6.6	62
Civil	36.0	56	0.6	**	8.7	83	20.7	104	6.1	**
Electrical	126.4	47	3.0	**	30.8	39	79.1	69	13.5	-7
Mechanical	105.0	48	12.8	516	23.1	98	47.5	14	21.6	41
Metallurgical/materials	46.0	-7	1.3	**	13.4	17	28.5	-14	2.8	**
Other, n.e.c.	107.4	16	2.3	**	**	-24	69.7	42	17.9	4
Agricultural sciences	67.4	54	0.6	**	17.7	49	44.6	66	4.5	**
Agronomic sciences	42.1	50	0.4	**	11.2	31	27.9	67	2.6	**
Animal sciences	11.6	12	0.1	**	3.5	**	7.4	8	0.5	**
Natural resources management	13.8	**	0.1	**	3.0	**	9.3	180	1.4	**
Biological sciences	716.0	48	17.8	276	203.6	55	439.9	46	53.8	12
In medical schools	402.0	38	8.8	229	115.0	47	245.4	35	32.7	16
In colleges/universities	313.0	62	8.9	344	88.5	67	194.5	62	21.0	22
Computer science	105.7	65	2.4	**	20.6	75	79.6	87	3.2	
Environmental sciences	199.7	50	8.4	232	61.4	65	108.3	38	21.7	
Materials science	48.2	26	2.1	**	11.2	-11	33.3	46	1.7	**
Physical sciences	648.1	28	21.6	255	156.0	44	387.1	26	83.5	-2
Chemistry	365.4	36	7.8	211	90.8	70	231.1	35	35.7	-13
Physics/astronomy	282.7	19	13.8	285	65.2	19	155.9	15	47.8	8
Interdisciplinary, n.e.c.	97.0	32	8.4	196	21.0	476	25.8	410	41.8	-32
INSTITUTION TYPE										
Colleges/universities	1,932.5	38	73.2	129	478.9	50	1,134.6	42	245.8	-2
Private	583.4	20	17.9	20	167.7	36	326.2	22	71.5	-11
Public	1,349.1	47	55.3	223	311.2	60	808.4	52	174.3	3
Top 20 in R&D	663.3	36	30.6	132	168.5	50	389.7	35	74.5	4
Not in top 20	1,269.2	39	42.7	127	310.4	50	744.9	47	171.2	-3
Medical schools	409.6	39	8.8	226	115.9	46	252.2	37	32.7	15

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedures, see Appendix F.

**Unstable estimate: 1982-83 base is less than $6 million.

SOURCE: National Science Foundation, SRS

Table B-4a. Aggregate purchase price of systems in the national stock, by system research status, field, and institution type: National estimates, 1982-83 and 1985-86 (inflation-adjusted)[1]

Field and institution type	System research status (aggregate purchase price; dollars in millions)									
	Total		Not yet-in use		In research use				Inactive/ Inoperable	
					State-of-the-art		Other			
	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]
Total	$1,604.9	$2,221.0	$31.1	$73.4	$371.3	$555.3	$939.4	$1,327.2	$263.1	$265.1
FIELD										
Engineering	328.5	432.9	12.0	18.6	74.8	95.6	186.5	253.6	55.3	65.2
Chemical	27.0	38.2	0.5	0.7	7.1	9.3	15.5	21.7	4.0	6.5
Civil	21.9	34.2	4.1	0.5	4.3	7.9	9.8	20.0	3.7	5.8
Electrical	79.9	117.8	2.2	2.8	20.4	28.3	44.2	74.6	13.0	12.1
Mechanical	67.2	99.3	1.9	11 7	10.7	21.3	39.8	45.4	14.8	20.9
Metallurgical/materials	46.0	42.8	0.9	0.9	10.3	12.0	31.6	27.1	3.3	2 7
Other, n.e.c.	86.5	100.7	2.4	2.0	22.0	16.8	45.6	64.7	16.5	17.1
Agricultural sciences	42.4	65.5	0.4	0.6	11.2	16.7	26.3	43.7	4.6	4 5
Agronomic sciences	27.3	40.9	0.1	0.4	8.1	10.6	16.3	27.2	2.8	2.6
Animal sciences	9.9	11.1	0.2	0.1	2.2	3.2	6.7	7.2	0.8	0.5
Natural resources management	5.3	13.5	0.1	0.1	0.9	2.9	3.3	9.2	1.0	1.3
Biological sciences	469.4	692.4	4.2	15.8	125.0	193.7	295.3	429 8	44.9	53.2
In medical schools	284.6	392.6	2.5	8.1	74.8	110.2	179.1	241.6	28.2	32.7
In colleges/universities	184.8	299.9	1.7	7.7	50.2	83.5	116.2	188.2	16.7	20.5
Computer science	59.4	97.9	3.1	2.0	10.7	18.7	39.7	74.3	5.9	2.8
Environmental sciences	124.7	187.5	2.2	7.3	34.4	57.0	74.4	102.8	13.6	20.4
Materials science	37.1	46.9	1.1	2.0	12.0	10.7	22.4	32.6	1.6	1.7
Physical sciences	477.1	610.5	5.6	19.7	100.0	144.4	290.3	367.1	81.2	79.3
Chemistry	251.8	343.2	2.2	7.0	49.0	83.6	161.5	218.6	39.1	34.0
Physics/astronomy	225.2	267.3	3.3	12.8	51.0	60.8	128.8	148.4	42.1	45 3
Interdisciplinary, n.e.c.	66.4	87.4	2.5	7.3	3.2	18.5	4.6	23.5	56 1	38.1
INSTITUTION TYPE										
Colleges/universities	1,316.6	1,820.8	28.6	65.3	295.3	444.3	758.0	1,078.8	234.8	232.4
Private	456.6	549.8	13.3	16.0	114.5	155.7	254.5	311.4	74 4	66.7
Public	860.0	1,271.0	15.3	49.3	180.9	288.6	503.5	767.4	160.4	165.7
Top 20 in R&D	472.1	643.4	12.2	28.3	106.4	160.1	282.7	381.4	70.8	73.6
Not in top 20	844.4	1,177.5	16.3	37.0	188.9	284.2	475.2	697.5	164.0	158.8
Medical schools	288.3	400.2	2.5	8.1	76.0	111.0	181.5	248.4	28.3	32.7

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedures, see Appendix F.

SOURCE: National Science Foundation, SRS

Table B-5. Median age of systems in the national stock, by system research status, field, and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	System research status (median age, in years)									
	Total		Not yet in use		In research use				Inactive/ Inoperable	
					State-of-the-art		Other			
	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total	5	5	<1	<1	2	2	5	5	11	12
FIELD										
Engineering	4	4	<1	<1	1	2	4	4	10	9
Chemical	4	4	**	**	1	2	4	5	**	12
Civil	5	5	**	**	**	1	6	5	**	**
Electrical	3	2	**	**	1	1	3	3	8	5
Mechanical	4	4	**	**	0	2	5	5	11	11
Metallurgical/materials	3	4	**	**	2	3	4	5	**	**
Other, n.e.c.	7	4	**	**	4	1	7	3	11	10
Agricultural sciences	4	5	**	**	2	2	5	5	**	**
Agronomic sciences	4	4	**	**	2	2	5	5	**	**
Animal sciences	4	5	**	**	**	**	5	6	**	**
Natural resources management	**	5	**	**	**	**	**	**	**	**
Biological sciences	5	5	**	<1	2	2	6	6	11	12
In medical schools	5	5	**	<1	2	2	6	6	11	12
In colleges/universities	5	5	**	<1	2	2	5	6	11	13
Computer science	2	2	**	**	0	1	2	2	**	**
Environmental sciences	4	4	**	<1	2	1	4	4	9	7
Materials science	10	7	**	**	1	2	11	9	**	**
Physical sciences	5	5	**	<1	2	1	5	5	12	13
Chemistry	5	5	**	<1	2	1	4	5	11	13
Physics/astronomy	6	5	**	<1	2	2	6	5	14	13
Interdisciplinary, n.e.c	9	8	**	<1	**	3	**	8	13	11
INSTITUTION TYPE										
Colleges/universities	5	4	<1	<1	2	2	5	5	11	12
Private	5	4	2	<1	1	2	4	5	13	16
Public	5	4	<1	<1	2	2	5	5	10	11
Top 20 in R&D	5	4	<1	<1	2	1	5	5	11	11
Not in top 20	5	5	1	<1	2	2	5	5	11	12
Medical schools	5	5	**	<1	2	2	6	6	11	12

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

**Unstable estimate: base is less than $6,000,000 of equipment.

SOURCE: National Science Foundation, SRS

Table B-6. Rates of acquisition and retirement of in-use research equipment, by field and institution type: National estimates, 1982-83 to 1985-86[1]

Field and institution type	Rates of acquisition and retirement of in-use systems			
	Systems in-use in 1982-83		Systems in-use in 1985-86	
	Total number	Percent retired by 1985-86	Total number	Percent acquired since 1982-83
Total	36,300	23%	53,900	37%
FIELD				
Engineering	6,800	27	9,300	44
Chemical	700	25	1,000	43
Civil	400	25	900	44
Electrical	1,500	31	2,500	54
Mechanical	1,300	33	1,700	36
Metallurgical/materials	1,100	17	1,100	28
Other, n.e.c.	1,800	25	1,900	50
Agricultural sciences	1,600	14	2,600	29
Agronomic sciences	1,000	12	1,700	29
Animal sciences	400	11	500	27
Natural resources management	200	31	400	31
Biological sciences	15,300	20	22,300	31
In medical schools	8,900	19	12,000	33
In colleges/universities	6,400	21	10,300	29
Computer science	900	42	2,200	75
Environmental sciences	2,100	28	3,300	39
Materials science	600	17	800	23
Physical sciences	8,800	24	12,300	38
Chemistry	4,800	22	7,000	36
Physics/astronomy	3,900	27	5,300	42
Interdisciplinary, n.e.c.	200	16	1,200	33
INSTITUTION TYPE				
Colleges/universities	27,300	24	41,800	38
Private	8,900	23	11,900	39
Public	18,500	24	29,800	38
Top 20 in R&D	10,000	24	14,600	40
Not in top 20	17,400	24	27,200	37
Medical schools	9,000	19	12,089	33

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

SOURCE: National Science Foundation, SRS

Table B-7. Trends in the number of in-use research systems, by field and institution type: National estimates, 1982-83 to 1985-86[1]

Field and institution type	Number of systems			
	1982 -83	1985-86		Percent change[2]
		Unadjusted	Adjusted[2]	
Total	36,300	53,900	51,900	43%
FIELD				
Engineering	6,800	9,300	8,800	30
Chemical	700	1,000	1,000	41
Civil	400	900	900	**
Electrical	1,500	2,500	2,400	59
Mechanical	1,300	1,700	1,700	23
Metallurgical/materials	1,100	1,100	1,100	-2
Other, n.e.c.	1,800	1,900	1,800	4
Agricultural sciences	1,600	2,600	2,500	52
Agronomic sciences	1,000	1,700	1,600	57
Animal sciences	400	500	500	**
Natural resources management	200	400	400	**
Biological sciences	15,300	22,300	21,800	42
In medical schools	8,900	12,000	11,800	33
In colleges/universities	6,400	10,300	10,000	55
Computer science	900	2,200	2,100	138
Environmental sciences	2,100	3,300	3,200	50
Materials science	600	800	800	22
Physical sciences	8,800	12,300	12,000	33
Chemistry	4,800	7,000	6,600	37
Physics/astronomy	3,900	5,300	5,000	28
Interdisciplinary, n.e.c	200	1,200	1,100	**
INSTITUTION TYPE				
Colleges/universities	27,300	41,800	40,000	46
Private	8,900	11,900	11,500	29
Public	18,500	29,800	28,500	54
Top 20 in R&D	10,000	14,600	14,400	42
Not in top 20	17,400	27,200	25,600	44
Medical schools	9,000	12,100	11,900	33

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

**Unstable estimate: 1982-83 base is less than 500 systems.

SOURCE: National Science Foundation, SRS

109

Table B-8. Trends in the aggregate purchase price of in-use research systems, by field and institution type: National estimates, 1982-83 to 1985-86[1]

Field and institution type	Aggregate purchase price (dollars in millions)			
	1982-83	1985-86		Percent change[2]
		Unadjusted	Adjusted[2]	
Total	$1,310.7	$1,981.6	$1,882.5	44%
FIELD				
Engineering	261.3	371.8	349.1	34
Chemical	22.6	32.8	30.9	37
Civil	14.1	29.3	27.9	98
Electrical	64.6	109.8	102.9	59
Mechanical	50.5	70.6	66.7	32
Metallurgical/materials	41.9	41.9	39.1	-7
Other, n.e.c	67.6	87.2	81.5	21
Agricultural sciences	37.5	62.3	60.4	61
Agronomic sciences	24.4	39.1	37.9	55
Animal sciences	8.9	10.9	10.5	18
Natural resources management	4.2	12.3	12.0	**
Biological sciences	420.3	643.4	623.5	48
In medical schools	253.9	360.4	351.8	39
In colleges/universities	166.3	283.0	271.7	63
Computer science	50.4	100.2	93.1	85
Environmental sciences	108.9	169.6	159.7	47
Materials science	34.4	44.5	43.3	26
Physical sciences	390.2	543.0	511.4	31
Chemistry	210.5	321.9	302.2	44
Physics/astronomy	179.7	221.1	209.2	16
Interdisciplinary, n.e.c	7.8	46.8	42.0	438
INSTITUTION TYPE				
Colleges/universities	1,053.3	1,613.5	1,523.1	45
Private	368.9	494.0	467.1	27
Public	684.3	1,119.6	1,056.0	54
Top 20 in R&D	389.1	558.2	541.4	39
Not in top 20	664.2	1,055.3	981.7	48
Medical schools	257.5	368.0	359.4	40

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

**Unstable estimate: 1982-83 base is less than $6 million.

SOURCE: National Science Foundation, SRS

110

Table B-9. Trends in the mean dollar amount of in-use research equipment per institution, by field and institution type: National estimates, 1982-83 to 1985-86[1]

Field and institution type	Mean purchase price per institution (dollars in thousands)			
	1982 -83	1985-86		Percent change[2]
		Unadjusted	Adjusted[2]	
Total	$5,306	$7,450	$7,382	39%
FIELD				
Engineering	1,686	2,136	2,142	27
Chemical	146	188	190	30
Civil	91	168	171	**
Electrical	417	631	631	51
Mechanical	326	406	409	25
Metallurgical/materials	270	241	240	-11
Other, n.e.c.	436	501	500	15
Agricultural sciences	242	358	371	53
Agronomic sciences	157	225	233	48
Animal sciences	57	63	64	**
Natural resources management	27	71	74	**
Biological sciences	1,702	2,419	2,445	44
In medical schools	2,760	3,917	3,824	39
In colleges/universities	1,073	1,626	1,667	[illegible]
Computer science	325	576	571	76
Environmental sciences	702	975	980	40
Materials science	222	256	266	20
Physical sciences	2,518	3,121	3,137	25
Chemistry	1,358	1,850	1,854	37
Physics/astronomy	1,160	1,271	1,283	11
Interdisciplinary, n.e.c	50	269	258	**
INSTITUTION TYPE				
Colleges/universities	6,795	9,273	9,344	38
Private	7,233	8,821	9,160	27
Public	6,580	9,488	9,429	43
Top 20 in R&D	19,455	27,910	27,070	39
Not in top 20	4,920	6,853	6,865	40
Medical schools	2,799	4,000	3,906	40

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

**Unstable estimate: 1982-83 base is less than $100,000 per institution.

SOURCE: National Science Foundation, SRS

Table B-10. Trends in the mean purchase price per system of in-use research equipment, by field and institution type: National estimates, 1982-83 to 1985-86[1]

Field and institution type	Mean purchase price per system (dollars in thousands)			
	1982 -83	1985-86		Percent change[2]
		Unadjusted	Adjusted[2]	
Total	$36.1	$36.8	$36.3	1%
FIELD				
Engineering	38.5	40.1	39.5	3
Chemical	33.5	33.7	32.5	-3
Civil	35.5	31.0	30.9	**
Electrical	42.4	43.3	42.5	0
Mechanical	37.6	40.6	40.3	7
Metallurgical/materials	38.5	37.3	36.7	-5
Other, n.e.c.	38.3	44.8	44.4	16
Agricultural sciences	22.7	24.2	24.0	6
Agronomic sciences	23.4	23.5	23.2	-1
Animal sciences	**	21.7	**	**
Natural resources management	**	**	**	**
Biological sciences	27.4	28.9	28.6	4
In medical schools	28 6	30.0	29.7	4
In colleges/universities	25.9	27.5	27.3	5
Computer science	57.8	46.0	44.8	-22
Environmental sciences	51.6	51.4	50.6	-2
Materials science	53.0	55.3	54.8	3
Physical sciences	44 6	44.1	43.9	-2
Chemistry	43.6	45.9	45.5	4
Physics/astronomy	45.8	41.7	41.6	-9
Interdisciplinary, n.e.c	**	39.8	39.0	**
INSTITUTION TYPE				
Colleges/universities	38.5	38.6	38.1	-1
Private	41.6	41.3	40.8	-2
Public	37.0	37.5	37.0	0
Top 20 in R&D	39.1	38.2	37.7	-4
Not in top 20	38.2	38.8	38.4	1
Medical schools	28.7	30.4	30.1	5

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

112

Table B-11. Means of acquisition of in-use research equipment, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	Means of acquisition (percent of in-use systems)											
		Purchased				Donated				Locally Built		Other	
		New		Used		New		Used					
		1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total	100%	89%	91%	4%	3%	1%	2%	1%	1%	3%	2%	2%	1%
FIELD													
Engineering	100	83	88	3	2	4	4	2	2	6	2	2	2
Chemical	100	96	93	3	3	*	1	*	1	*	1	1	1
Civil	100	**	91	**	1	**	1	**	2	**	4	**	1
Electrical	100	79	83	3	2	6	9	2	2	5	2	4	2
Mechanical	100	85	86	1	2	1	3	1	5	10	3	*	*
Metallurgical/materials	100	89	91	2	2	*	1	4	1	3	1	2	4
Other, n.e.c.	100	74	88	5	2	11	4	1	1	7	3	3	2
Agricultural sciences	100	95	95	2	3	*	*	*	*	1	1	1	*
Agronomic sciences	100	97	96	2	2	*	*	*	*	1	1	*	1
Animal sciences	100	**	95	**	5	**	*	**	*	**	*	**	*
Natural resources mgmt	100	**	**	**	**	**	**	**	**	**	**	**	**
Biological sciences	100	94	94	3	3	*	*	*	*	*	*	2	1
In medical schools	100	94	94	3	3	*	*	*	*	*	*	2	2
In colleges/universities	100	94	94	4	4	*	*	*	*	1	*	1	1
Computer science	100	88	87	6	1	3	11	3	1	*	*	*	*
Environmental sciences	100	83	88	5	2	1	1	1	2	5	5	5	1
Materials science	100	95	87	3	6	*	*	*	3	1	4	*	*
Physical sciences	100	86	89	5	3	*	1	1	1	4	3	3	3
Chemistry	100	86	91	7	4	*	1	2	1	1	1	4	3
Physics/astronomy	100	85	88	3	2	*	*	*	1	8	6	4	3
Interdisciplinary, n.e.c.	100	**	77	**	6	**	13	**	*	**	*	**	4
INSTITUTION TYPE													
Colleges/universities	100	88	90	4	3	1	2	1	1	3	2	2	1
Private	100	87	90	3	3	1	2	2	1	5	3	2	2
Public	100	88	90	4	3	2	2	1	1	2	2	3	2
Top 20 in R&D	100	89	89	3	2	1	3	1	1	3	3	2	1
Not in top 20	100	87	90	5	3	2	2	1	1	3	2	2	2
Medical schools	100	94	94	3	3	*	*	*	*	*	*	2	2

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

*Less than 0.5%

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-12. Federal involvement in funding of in-use research equipment, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	Federal funding involvement (percent of in-use systems)					
		No Federal funding		Partial Federal funding		100% Federal funding	
		1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	100%	40%	45%	17%	15%	43%	40%
FIELD							
Engineering	100	47	54	18	16	35	30
Chemical	100	36	48	22	18	42	34
Civil	100	**	68	**	18	**	14
Electrical	100	26	48	16	15	58	37
Mechanical	100	37	53	21	15	42	31
Metallurgical/materials	100	45	50	32	24	23	27
Other, n.e.c.	100	72	61	9	12	19	28
Agricultural sciences	100		74	10	9	19	17
Agronomic sciences	100	75	77	9	7	16	16
Animal sciences	100	**	72	**	13	**	15
Natural resources management	100	**	**	**	**	**	**
Biological sciences	100	41	44	11	12	47	44
In medical schools	100	41	42	10	10	49	48
In colleges/universities	100	42	46	13	15	44	39
Computer science	100	45	41	27	5	27	54
Environmental sciences	100	43	42	17	15	40	43
Materials science	100	13	20	32	35	55	45
Physical sciences	100	26	32	25	22	49	46
Chemistry	100	36	37	30	27	34	36
Physics/astronomy	100	13	25	20	16	67	59
Interdisciplinary, n.e.c.	100	**	85	**	7	**	8
INSTITUTION TYPE							
Colleges/universities	100	40	45	20	16	41	38
Private	100	27	32	21	17	52	50
Public	100	45	51	19	16	36	33
Top 20 in R&D	100	38	44	17	15	45	42
Not in top 20	100	41	46	21	17	38	36
Medical schools	100	41	42	10	10	50	47

[1] For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-13. Aggregate purchase price of in-use research equipment, by source of funds, field, and institution type: National estimates, 1985-86 and percent change from 1982-83[1]

Field and institution type	Source of funds (aggregate purchase price; dollars in millions)[3]											
	Total, all reported sources		Federal government		Institution funds		State government		Business/ donations		Other	
	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]
Total	$1,884.2	42%	$906.[illegible]	30%	$579.8	47%	$114.3	72%	$239.2	69%	$44.7	61%
FIELD												
Engineering	360.7	34	136.7	13	106.3	25	28.9	94	80.6	87	8.2	43
Chemical	31.9	37	16.8	16	9.6	70	0.7	**	4.9	**	0.1	**
Civil	26.8	95	6.9	**	14.5	11	1.3	**	2.2	**	2.0	**
Electrical	107.3	66	40.6	3	23.0	101	7.0	**	35.7	187	1.1	**
Mechanical	69.1	31	26.2	4	19.5	34	8.2	**	13.4	52	1.8	**
Metallurgical/materials	41.0	-7	19.9	4	10.3	-5	4.7	-25	5 3	-1	0.8	**
Other, n.e.c.	84.5	18	26.4	34	29.4	-11	7.0	**	19.2	45	2.6	**
Agricultural sciences	60.3	58	14.3	73	27.1	46	12.1	74	5.6	**	1.2	**
Agronomic sciences	38.0	53	8.0	66	19.5	60	12.1	34	56.0	**	1.2	66
Animal sciences	10.4	14	2.0	**	4.2	-11	3.0	**	1.2	**	*	**
Natural resources management	11.9	178	4.3	**	3.4	**	2.3	**	1.8	**	0.2	**
Biological sciences	605.0	43	298.6	43	208.6	49	38.4	93	48.3	53	11.0	3
In medical schools	333.5	37	174.3	41	109.6	23	14.4	139	29.0	59	6.3	-5
In colleges/universities	271.5	62	124.4	47	99.0	93	24.0	72	19.3	45	4.7	17
Computer science	93.6	74	48.9	109	21.5	71	3.1	-42	19.7	61	0.4	**
Environmental sciences	166.1	47	77.7	45	44.8	53	11.2	36	27.2	39	5.2	**
Materials science	40.8	15	26.2	5	10.1	61	0.9	**	1.8	**	1.7	**
Physical sciences	513.6	30	298.9	18	142.8	43	18.2	156	41.4	42	12.4	84
Chemistry	305.1	44	157.6	39	96.3	30	14.5	132	27.7	78	9.0	**
Physics/astronomy	208.6	13	141.3	1	46.5	80	3.7	**	13.7	2	3.4	-6
Interdisciplinary, n.e.c.	44.0	405	4.8	**	18.6	**	1.5	**	14 5	**	4.6	**
INSTITUTION TYPE												
Colleges/universities	1543 5	43	30 0	28	465.6	53	99.9	66	209 6	70	38.4	83
Private	466.3	24	276.6	19	98.6	28	1.9	**	79 3	36	9.9	52
Public	1077.2	53	453.4	34	367.1	61	98.0	66	130 0	101	28.5	97
Top 20 in R&D	540.2	38	267 5	25	160.0	36	26 5	88	76.6	97	9.6	26
Not in top 20	1003 3	46	462.4	30	305.7	64	73.4	58	133.0	57	28 8	118
Medical schools	340.7	38	176.3	41	114.1	27	14 4	131	29 5	60	6 3	-5

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

[3]Table excludes systems for which funding sources wre unavailable. The effect is to underestimate dollar amounts 4-5 percent on average.

*Less than $50,000.

**Unstable estimate: 1982-83 base is less than $4 million.

SOURCE: National Science Foundation, SRS

Table B-13a. Aggregate purchase price of in-use research equipment, by source of funds, field, and institution type: National estimates, 1982-83 and 1985-86 (inflation-adjusted)[1]

Field and institution type	Source of funds (aggregate purchase price; dollars in millions)[3]											
	Total, all reported sources		Federal government		Institution funds		State government		Business/ industry		Other	
	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]	1982 -83	1985 -86[2]
Total	$1260.8	$1789.8	$662.7	$863.4	$375.7	$551.6	$62.0	$106.6	134.1	$225.9	$26 3	$42.2
FIELD												
Engineering	253.3	338.8	114.0	129.3	80.0	100.4	13.4	26.0	40.3	75.2	5.6	8.0
Chemical	22.1	30.1	13.5	15.7	5.4	9.2	1.0	0.6	2.1	4.5	0.1	0.1
Civil	13.0	25.5	2.5	6.5	7.9	13.6	1.2	1.3	1.2	2 1	0.2	2.0
Electrical	60.7	100.6	37.3	38.4	10.7	21.4	0.8	6.4	11.6	33.4	0.3	1.0
Mechanical	49.7	65.3	23.9	24.8	14.0	18.7	1.8	7.5	8.3	12.6	1.7	1.7
Metallurgical/materials	41.1	38.3	17.9	18.7	10.3	9.8	5.7	4 3	4.8	4.7	2.4	1.0
Other, n.e.c.	66.8	79.2	18.8	25.2	31.8	27.7	2.9	5.9	12.3	17.9	1.0	2.5
Agricultural sciences	36.9	58.4	8.0	13.9	17.9	26.3	6.7	11.8	3.3	5.4	1.0	1.1
Agronomic sciences	24.1	36.8	4.7	7.7	11.9	19.0	5.0	6.6	1.9	2.5	0.6	1.0
Animal sciences	8.8	100	2.1	1.9	4.4	4.0	1.1	2.9	1.0	1.2	0.2	*
Natural resources management	4.1	11.6	1.3	4.2	1.6	3.3	0.6	2.2	0.4	1.7	0.2	0.2
Biological sciences	398.4	586.1	202.0	289.3	136.1	202.2	18.9	36.5	30.8	47.2	10.6	11.0
In medical schools	237.7	325.6	120.5	169.8	87.0	107.3	5.8	13.9	[illegible]	28.4	6.6	6.2
In colleges/universities	160.7	260.5	81.5	119.5	49.2	94.9	13.1	22.6	12.9	18 8	4.0	4.7
Computer science	50.2	87.2	21.9	45.7	11.7	20.0	4.8	2.8	11.4	18.3	0.4	0.4
Environmental sciences	106.5	156.3	49.8	72.3	27.7	42.5	7.7	10.5	18.9	26.2	2.4	4.8
Materials science	34.4	39.7	24.3	25.6	6.1	9.8	2.6	0 9	1.2	1.8	0.2	1.6
Physical sciences	373.1	483.7	239.9	283.0	93.3	133.7	6.6	16.9	27.1	38.7	6.2	11.4
Chemistry	199.1	286.3	106.7	148.7	69.3	90.4	5.8	13.4	14 5	25 7	2 8	8.1
Physics/astronomy	[illegible]	197.3	133.2	134.4	24.1	[illegible]	0.8	3.5	12.7	12.9	3.4	3.2
Interdisciplinary, n.e.c.	7.8	39.5	2.9	4.3	2.7	16 7	1.2	1 3	1 0	13.1	*	4.0
INSTITUTION TYPE												
Colleges/universities	1020.1	1457.0	540.4	691.5	287.9	439.7	56.0	92 7	116 1	197.0	19.7	36.0
Private	355.6	441.5	219.6	261.8	73.2	93.4	1.3	1 9	55 4	75.1	6 1	9.3
Public	664.4	1015.4	320.7	429.7	214.8	346 3	54.7	90.8	60.7	121.9	13 5	26.7
Top 20 in R&D	380.6	523.8	207.8	259.9	114.6	155.6	13 8	25.9	37.0	73.1	7 4	9.4
Not in top 20	639.4	933.2	332.6	431.6	173.4	284.2	42.2	66.8	79 0	123 9	12.2	26.6
Medical schools	240.6	332.8	122.3	171.9	87.7	111.8	6 0	13.9	18.0	28.9	6.6	6.2

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

[3]Table excludes systems for which funding sources were unavailable. The effect is to underestimate dollar amounts by 4-5 percent on average.

*Less than $50,000.

SOURCE: National Science Foundation, SRS

Table B-14. Aggregate purchase price of Federally-funded, in-use research equipment, by funding agency, field, and institution type: National estimates, 1985-86 and percent change from 1982-83[1]

Field and institution type	Funding agency (aggregate purchase price; dollars in millions)[3]											
	NSF		NIH		DOD		DOE		USDA		All others	
	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]	1985 -86	Percent change[2]
Total	$306.1	26%	$269.6	46%	$141.6	28%	$90.1	36%	$7.2	39%	$91.7	7%
FIELD												
Engineering	37.6	1	5.4	**	59.4	16	16.9	15	0.1	**	$17.3	21
Chemical	6.9	19	0.3	**	6.0	1	2.8	**	*	**	0.8	**
Civil	3.6	**	*	**	0.8	**	0.5	**	*	**	2.1	**
Electrical	10.9	4	0.7	**	23.1	11	1.6	**	*	**	4.4	-13
Mechanical	6.8	-12	0.2	**	15.9	23	1.2	**	*	**	2.2	**
Metallurgical/materials	5.0	-34	*	-100	7.0	**	3.9	-27	*	**	3.9	**
Other, n.e.c	4.5	**	4.3	**	6.5	-25	7.0	**	0.1	**	4.0	**
Agricultural sciences	3.8	**	1.8	**	0.2	**	1.1	**	3.6	**	3.9	**
Agronomic sciences	2.3	**	0 8	**	0 1	**	0.9	**	2.2	**	1.8	**
Animal sciences	0.3	**	1.0	**	*	**	*	**	0 6	**	*	**
Natural resources management	1.2	**	*	**	*	**	0.2	**	0.8	**	2.1	**
Biological sciences	50.7	39	226.5	44	6.7	**	4.4	**	3.0	**	7.3	3
In medical schools	18.8	66	147.9	41	2.0	**	2.0	**	0.2	**	3.4	**
In colleges/universities	31.9	26	78.6	51	4.7	**	2.5	**	2.8	**	3.9	-7
Computer science	25.9	123	1.0	**	19.8	99	0 5	**	*	**		**
Environmental sciences	29.8	71	0.5	**	10.2	44	15.0	70	0.2	**	*	11
Materials science	18.6	33	*	**	2.9	-49	3.7	**	*	**	1.1	**
Physical sciences	138.9	13	33.2	58	42.3	25	46.0	31	0 3	**	38.3	-3
Chemistry	85 4	22	32.1	64	14.8	54	17.1	186	0.3	**	7.9	8
Physics/astronomy	53.5	1	1.1	**	27 5	13	28 9	0	*	**	30.4	-6
Interdisciplinary, n.e.c	1 1	**	1 1	**	0 1	**	2.4	**	*	**	0 1	**
INSTITUTION TYPE												
Colleges/universities	287.3	24	119 6	54	139.6	28	88 1	39	7.1	40	88 3	6
Private	117.7	14	48.7	50	64 0	16	16.6	24	0 5	**	29 1	8
Public	169.6	32	70 9	56	75 6	41	71.5	43	6 6	39	59.2	5
Top 20 in R&D	115.5	28	43 8	42	53.3	29	27 6	25	4 6	**	22.7	-16
Not in top 20	171.8	21	75 8	62	86 3	27	60 5	47	2 4	**	65.6	17
Medical schools	18.8	64	150 0	40	2 0	**	2 0	**	0 2	**	3.4	**

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedures, see Appendix F.

[3]Table excludes systems for which funding sources were unavailable. The effect is to underestimate dollar amounts by 4-5 percent on average.

*Less than $50,000.

**Unstable estimate: 1982-83 base is less than $4 million.

SOURCE: National Science Foundation, SRS

Table B-14a. Aggregate purchase price of Federally-funded in-use research equipment, by funding agency, field, and institution type: National estimates, 1982-83 and 1985-86 (inflation-adjusted)[1]

Field and institution type	Funding agency aggregate purchase price (dollars in millions)[3]											
	NSF		NIH		DOD		DOE		USDA		All others	
	1982-83	1985-86[2]	1982-83	1985-86[2]	1982-83	1985-86[2]	1982-83	1985-86[2]	1982-83	1985-86[2]	1982-83	1985-86[2]
Total	$232.7	$292.8	$178.1	$259.9	$104.2	$133.5	$62.1	$84.1	$5.1	$7.1	$80.6	$85.9
FIELD												
Engineering	35.4	35.9	2.9	5.2	48.4	56.1	13.8	15.9	0 3	0.1	13.2	16.0
Chemical	5.6	6.7	0.2	0.3	5.5	5.5	1.2	2.4	*	*	0.9	0.7
Civil	1.6	3.4	*	*	0.1	0.8	0.4	0.5	*	*	0.3	1.8
Electrical	10.1	10.5	1.2	0.7	19.6	21.6	1.7	1.5	*	*	4.7	4.1
Mechanical	7.0	6.2	*	0.2	12.4	15.2	3.0	1.2	*	*	1.5	2 1
Metallurgical/materials	7.4	4.9	*	*	2.4	6.7	5.0	3.6	*	*	3.1	3.5
Other, n.e.c.	3.6	4.2	1.5	4.1	8.4	6.3	2.5	6.7	0.3	0.1	2.6	3.8
Agricultural sciences	1.7	3.7	1.3	1.8	*	0.2	0.3	1.0	2 8	3.5	1.9	3.8
Agronomic sciences	0.9	2.2	0.6	0.8	*	0.1	0.2	0.8	1 7	2.1	1.3	1.7
Animal sciences	0.2	0.5	0.8	1.0	*	*	*	*	0 9	0 6	0.2	*
Natural resources management	0.6	1.2	*	*	*	*	*	0.2	0 2	0.8	0.4	2.0
Biological sciences	35.2	48.9	152.5	219 8	2.1	6.1	3.3	4.3	1 9	2.9	6.9	7.1
In medical schools	11.0	18.3	102.6	144.2	1.2	1.8	2.7	1.9	0 2	0 2	2.8	3.4
In colleges/universities	24.2	30.6	49.9	75.6	1.0	4.3	0.7	2.4	1.7	2.8	4.1	3.8
Computer science	10.8	24.1	0.3	1.0	9.4	18.6	0.3	0.5	*	*	1.1	1.5
Environmental sciences	16.5	28.2	0.5	0.4	6.6	9.5	8.1	13.8	*	0.2	18.1	20.2
Materials science	13.5	18.0	0.7	*	5.4	2.8	3.4	3.7	*	*	1.3	1.1
Physical sciences	118.0	132.9	19.5	30.7	32.2	40.2	32.9	42.9	0 1	0.3	37.2	36.0
Chemistry	67.0	81.7	18.1	29.6	9.1	14.0	5.4	15.5	0 1	0 3	7.0	7.6
Physics/astronomy	51.0	51.3	1.4	1.1	23.1	26.2	27.5	27.4	*	*	30 2	28.4
Interdisciplinary, n.e.c.	1.5	1.1	0.5	0.9	*	0.1	*	2.0	*	*	0 8	0.1
INSTITUTION TYPE												
Colleges/universities	221.5	274.5	73.9	113.6	103.0	131.8	59.2	82.1	4 9	6 9	77.8	82.6
Private	98.2	111.5	31.2	46.7	52.4	60.6	12 5	15.5	0 3	0 5	25.1	27.1
Public	123.3	163.1	42.8	66.9	50.6	71.2	46.7	66.6	4 6	6 4	52.7	55.5
Top 20 in R&D	88.0	112.6	29.9	42.5	39.7	51 2	21.5	26 9	2 5	4 5	26.3	22 2
Not in top 20	133.6	161.9	44.0	71 2	63.3	80.5	37.7	55.3	2 4	2.4	51.5	60.4
Medical schools	1. 2	18.3	104.1	146.3	1 2	1.8	2 8	2 0	0 2	0 2	2 8	3.4

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimate is adjusted for inflation. For procedure, see Appendix F.

[3]Table excludes systems for which funding sources were unavailable. The effect is to underestimate dollar amounts by 4-5 percent on average.

*Less than $50,000.

SOURCE: National Science Foundation, SRS

Table B-15. Trends in the mean dollar amount of in-use research equipment per institution, by source of funds, field, and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Federal sources: 1982-83	Federal sources: 1985-86 Unadjusted	Federal sources: 1985-86 Adjusted[2]	Federal sources: Percent change[2]	Non-Federal sources: 1982-83	Non-Federal sources: 1985-86 Unadjusted	Non-Federal sources: 1985-86 Adjusted[2]	Non-Federal sources: Percent change[2]
	Mean purchase price per institution (dollars in thousands)[3]							
Total	$2,683	$3,407	$3,386	26%	$2,421	$3,676	$3,633	50%
FIELD								
Engineering	735	786	793	8	899	1,287	1,286	43
Chemical	87	96	96	11	55	87	88	61
Civil	16	40	40	**	68	115	117	72
Electrical	241	234	235	-2	151	383	382	153
Mechanical	154	151	152	-1	167	247	248	49
Metallurgical/materials	116	114	115	-1	149	121	120	-20
Other, n.e.c.	122	151	154	27	310	334	331	7
Agricultural sciences	52	82	85	65	187	264	273	46
Agronomic sciences	30	46	48	**	125	172	178	43
Animal sciences	14	11	12	**	43	49	50	**
Natural resources management	8	25	26	**	19	44	45	**
Biological sciences	818	1,123	1,134	39	795	1,152	1,164	46
In medical schools	1,309	1,894	1,846	41	1274	1,731	1,694	33
In colleges/universities	526	715	733	39	511	846	865	69
Computer science	141	281	281	99	182	257	255	40
Environmental sciences	321	447	444	38	366	508	515	41
Materials science	157	151	157	0	65	84	86	33
Physical sciences	1,548	1,718	1,736	12	860	1,234	1,231	43
Chemistry	689	906	912	32	595	847	845	42
Physics/astronomy	859	812	824	-4	264	386	386	46
Interdisciplinary, n.e.c.	19	28	26	**	32	225	216	**
INSTITUTION TYPE								
Colleges/universities	3,486	4,195	4,243	22	3,094	4,676	4,696	52
Private	4,306	4,939	5,134	19	2,665	3,388	3,524	32
Public	3,084	3,842	3,837	24	3,305	5,287	5,230	58
Top 20 in R&D	10,391	13,377	12,995	25	8,642	13,634	13,193	53
Not in top 20	2463	3,003	3,018	23	2,272	3,512	3,507	54
Medical schools	1,329	1,917	1,868	41	1,287	1,786	1,749	36

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

[3]Table excludes systems for which funding sources were unavailable. The effect is to underestimate dollar amount by 4-5 percent on average.

**Unstable estimate: 1982-83 base is less than $50,000 per institution per source.

SOURCE: National Science Foundation, SRS

Table B-16. Age distribution of in-use research equipment, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	System age (percent of in-use systems)							
		Under 3 years		3 - 5 years		6 - 8 years		Over 8 years	
		1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total	100%	35%	37%	27%	26%	13%	17%	25%	20%
FIELD									
Engineering	100	41	44	26	27	9	15	24	13
Chemical	100	46	43	32	24	6	22	17	11
Civil	100	**	44	**	20	**	11	**	25
Electrical	100	55	54	29	31	5	8	12	8
Mechanical	100	37	36	27	33	7	16	30	15
Metallurgical/materials	100	42	28	29	34	7	22	22	16
Other, n.e.c.	100	30	50	21	19	17	20	32	11
Agricultural sciences	100	36	29	32	31	15	21	18	19
Agronomic sciences	100	35	29	31	32	15	20	18	18
Animal sciences	100	**	27	**	30	**	22	**	21
Natural resources management	100	**	**	**	**	**	**	**	**
Biological sciences	100	31	31	27	26	16	19	26	25
In medical schools	100	30	33	27	24	17	18	26	25
In colleges/universities	100	33	29	27	28	14	19	26	24
Computer science	100	77	75	17	22	4	2	1	1
Environmental sciences	100	33	39	33	29	15	18	19	14
Materials science	100	26	23	13	21	11	10	50	47
Physical sciences	100	32	38	27	24	11	17	29	20
Chemistry	100	34	36	30	26	13	19	23	19
Physics/astronomy	100	30	42	24	22	10	14	36	22
Interdisciplinary, n.e.c	100	**	33	**	17	**	15	**	35
INSTITUTION TYPE									
Colleges/universities	100	36	38	27	26	12	16	25	19
Private	100	40	39	25	29	11	15	24	17
Public	100	34	38	28	25	13	17	25	20
Top 20 in R&D	100	35	40	28	25	13	16	24	19
Not in top 20	100	37	37	27	27	11	17	25	19
Medical schools	100	30	33	27	24	17	18	26	25

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

**Unstable estimate: base is less than 50^ systems.

SOURCE: National Science Foundation, SRS

Table B-17. Condition of in-use research equipment, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	General working condition (percent of systems)					
		Excellent		Average		Poor	
		1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	100%	52%	55%	38%	38%	10%	7%
FIELD							
Engineering	100	51	54	40	40	9	6
Chemical	100	39	52	48	40	14	7
Civil	100	**	54	**	37	**	9
Electrical	100	54	54	36	41	10	5
Mechanical	100	53	55	43	39	4	6
Metallurgical/materials	100	55	49	34	45	11	7
Other, n.e.c.	100	52	58	38	37	10	4
Agricultural sciences	100	56	54	37	40	7	6
Agronomic sciences	100	59	56	35	39	6	5
Animal sciences	100	**	53	**	8	**	9
Natural resources management	100	**	**	**	**	**	**
Biological sciences	100	53	56	38	37	9	8
In medical schools	100	52	57	39	36	10	7
In colleges/universities	100	55	54	37	37	8	8
Computer science	100	56	45	37	49	7	6
Environmental sciences	100	50	67	42	28	8	5
Materials science	100	32	40	51	47	17	14
Physical sciences	100	52	54	35	40	13	7
Chemistry	100	51	53	35	39	14	8
Physics/astronomy	100	53	54	35	41	12	5
Interdisciplinary, n.e.c.	100	**	71	**	27	**	2
INSTITUTION TYPE							
Colleges/universities	100	52	55	38	38	10	7
Private	100	54	52	35	41	10	7
Public	100	51	56	39	37	10	7
Top 20 in R&D	100	51	55	38	38	11	7
Not in top 20	100	52	55	38	39	10	7
Medical schools	100	52	57	39	36	10	7

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-18. Percent of in-use research equipment in excellent working condition, by system age, field, and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	System age (percent of systems in excellent condition)									
	Total		Under 3 years		3 - 5 years		6 - 8 years		Over 8 years	
	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total	52%	55%	74%	72%	56%	58%	36%	44%	27%	31%
FIELD										
Engineering	51	55	72	69	52	53	27	40	23	28
Chemical	39	52	56	72	27	50	10	29	25	26
Civil	**	54	**	77	**	31	**	65	**	29
Electrical	54	54	72	61	44	55	8	27	16	32
Mechanical	54	56	79	64	51	62	45	43	28	36
Metallurgical/materials	55	49	77	67	67	47	30	45	5	26
Other, n.e.c.	52	58	77	79	69	52	26	39	32	14
Agricultural sciences	56	54	76	77	56	64	28	32	41	27
Agronomic sciences	59	56	79	75	62	65	26	39	43	28
Animal sciences	**	53	**	81	**	69	**	24	**	24
Natural resources management	**	**	**	**	**	**	**	**	**	**
Biological sciences	53	56	78	78	59	60	38	45	26	32
In medical schools	51	57	77	76	57	64	33	48	28	31
In colleges/universities	55	54	78	79	61	57	45	41	24	32
Computer science	56	45	57	47	62	41	36	34	*	21
Environmental sciences	50	67	67	80	46	70	36	51	39	44
Materials science	32	40	77	76	39	61	13	25	11	16
Physical sciences	52	54	74	73	55	53	41	44	29	26
Chemistry	51	53	73	71	52	56	40	38	24	30
Physics/astronomy	53	54	74	75	60	48	44	55	33	21
Interdisciplinary, n.e.c	**	71	**	62	**	86	**	73	**	70
INSTITUTION TYPE										
Colleges/universities	52	55	73	71	55	57	37	43	27	31
Private	54	52	75	70	54	51	36	42	29	23
Public	51	56	71	71	56	59	38	43	25	34
Top 20 in R&D	51	55	73	70	50	60	38	37	27	33
Not in top 20	53	55	72	72	58	55	37	45	26	30
Medical schools	52	57	78	76	57	63	33	48	28	31

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

*Less than 0.5%.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-19. Percent of in-use research equipment in excellent working condition, by system research status, field, and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	System research status (percent of systems in excellent condition)					
	Total		State-of-the-art systems		Other in-use systems	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	52%	55%	84%	84%	43%	46%
FIELD						
Engineering	51	54	85	81	40	45
Chemical	39	52	77	78	29	44
Civil	**	54	**	[illegible]	**	47
Electrical	54	54	92	82	41	45
Mechanical	53	55	82	85	43	42
Metallurgical/materials	55	49	[illegible]	66	48	43
Other, n.e.c.	52	58	83	91	38	50
Agricultural sciences	56	54	81	88	47	44
Agronomic sciences	59	56	82	91	50	45
Animal sciences	**	53	**	83	**	41
Natural resources management	**	**	**	**	**	**
Biological sciences	53	56	86	85	44	46
In medical schools	52	57	83	88	43	47
In colleges/universities	55	54	90	81	44	46
Computer science	56	45	89	75	47	38
Environmental sciences	50	67	82	87	40	59
Materials science	32	40	74	83	23	31
Physical sciences	52	54	84	84	44	44
Chemistry	51	53	87	86	43	43
Physics/astronomy	53	54	81	81	45	45
Interdisciplinary, n.e.c.	47	71	44	80	49	61
INSTITUTION TYPE						
Colleges/universities	52	55	85	82	42	46
Private	54	52	84	81	44	41
Public	51	56	85	83	42	47
Top 20 in R&D	51	55	82	82	44	47
Not in top 20	52	55	86	83	42	45
Medical schools	52	57	83	89	44	46

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

**Unstable estimate: base is less than 500 systems

SOURCE: National Science Foundation, SRS

Table B-20. Percent of in-use systems that are the most advanced accessible to their users, by system research status, field, and institution type. National estimates, 1982-83 and 1985-86[1]

Field and institution type	System research status (percent of systems that are the most advanced accessible to their users)					
	Total		State-of-the-art systems		Other in-use systems	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	58%	52%	97%	93%	46%	38%
FIELD						
Engineering	61	56	96	97	50	43
Chemical	58	62	96	97	48	50
Civil	**	55	**	90	**	43
Electrical	54	52	93	98	41	38
Mechanical	62	56	94	96	50	40
Metallurgical/materials	63	56	98	98	56	42
Other, n.e.c.	69	60	98	99	56	49
Agricultural sciences	66	55	94	95	56	43
Agronomic sciences	67	53	97	96	56	39
Animal sciences	**	63	**	92	**	51
Natural resources management	**	**	**	**	**	**
Biological sciences	55	50	97	92	43	36
In medical schools	54	49	98	91	42	35
In colleges/universities	56	51	97	92	44	37
Computer science	61	44	99	87	50	33
Environmental sciences	60	51	98	88	47	37
Materials science	46	41	100	99	35	28
Physical sciences	58	53	97	94	49	40
Chemistry	61	55	98	96	52	43
Physics/astronomy	56	49	96	92	45	35
Interdisciplinary, n.e.c.	**	65	**	97	**	31
INSTITUTION TYPE						
Colleges/universities	59	53	97	94	48	39
Private	60	54	97	94	48	38
Public	58	52	96	94	48	39
Top 20 in R&D	54	51	95	95	44	37
Not in top 20	61	54	97	93	50	40
Medical schools	54	49	98	91	42	35

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-21. Location of in-use research equipment, by research field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	Within-department lab of individual principal investigator		Department-managed common lab		Non-departmental installation		National or regional lab		Other	
		1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	100%	59%	56%	32%	31%	6%	8%	1%	4%	1%	1%
FIELD											
Engineering	100	50	49	40	36	6	10	1	3	3	1
Chemical	100	74	76	22	24	2	*	*	*	2	*
Civil	100	**	34	**	50	**	8	**	7	**	1
Electrical	100	67	50	21	36	9	9	2	2	1	3
Mechanical	100	43	49	44	43	10	6	1	2	2	*
Metallurgical/materials	100	55	35	31	31	7	32	1	2	6	1
Other, n.e.c.	100	30	50	62	34	4	[illegible]	*	7	5	1
Agricultural sciences	100	64	56	31	37	4	5	1	1	1	1
Agronomic sciences	100	[illegible]	57	25	34	3	7	1	2	2	*
Animal sciences	100	**	62	**	33	**	2	**	*	**	2
Natural resources mgmt	100	**	**	**	**	**	**	**	**	**	**
Biological sciences	100	64	61	31	30	4	[illegible]	1	3	*	1
In medical schools	100	64	61	32	30	4	4	1	4	*	1
In colleges/universities	100	65	62	30	30	4	5	1	2	*	1
Computer science	100	20	37	65	53	14	6	*	3	1	2
Environmental sciences	100	52	51	28	28	13	5	3	9	4	8
Materials science	100	19	23	27	29	48	43	6	4	*	2
Physical sciences	100	65	64	24	25	6	4	2	6	2	*
Chemistry	100	62	63	30	29	4	5	2	3	1	*
Physics/astronomy	100	69	66	17	21	9	4	3	9	3	*
Interdisciplinary, n.e.c.	100	**	6	**	7	**	74	**	13	**	*
INSTITUTION TYPE											
Colleges/universities	100	58	55	32	31	7	9	2	4	2	1
Private	100	60	65	27	25	9	5	2	4	1	1
Public	100	56	51	34	33	6	10	1	4	2	1
Top 20 in R&D	100	58	54	29	32	10	9	2	4	2	1
Not in top 20	100	57	56	33	30	6	8	1	4	2	1
Medical schools	100	64	61	32	30	4	4	1	4	*	1

Location (percent of systems)

[1] For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

*Less than 0.5%.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-22. Percent of in-use research equipment in shared-access locations, by system research status, field, and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	System research status (percent of systems in shared-access locations)[2]					
	Total		State-of-the-art systems		Other in-use systems	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	41%	44%	38%	43%	42%	44%
FIELD						
Engineering	50	51	50	47	50	52
Chemical	26	24	29	23	25	24
Civil	**	65	**	50	**	71
Electrical	33	50	24	44	36	51
Mechanical	57	51	43	48	61	52
Metallurgical/materials	45	65	35	72	47	63
Other, n.e.c.	70	50	86	48	64	50
Agricultural sciences	36	45	31	55	38	41
Agronomic sciences	31	43	28	59	32	38
Animal sciences	**	38	**	49	**	33
Natural resources management	**	**	**	**	**	**
Biological sciences	36	39	32	36	36	39
In medical schools	36	39	35	37	37	40
In colleges/universities	35	38	29	35	36	39
Computer science	80	64	73	67	83	63
Environmental sciences	48	49	46	53	49	48
Materials science	81	77	73	84	83	76
Physical sciences	35	36	27	31	36	37
Chemistry	38	37	31	30	39	39
Physics/astronomy	31	34	22	33	33	35
Interdisciplinary, n.e.c.	**	94	**	96	**	92
INSTITUTION TYPE						
Colleges/universities	42	45	39	45	44	45
Private	40	35	37	33	41	36
Public	44	49	40	50	45	48
Top 20 in R&D	42	46	39	50	43	45
Not in top 20	43	44	39	42	44	45
Medical schools	36	39	35	37	36	40

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Shared-access locations are locations other than within-department laboratories of principal investigators.

**Unstable estimate: base less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-23. Percent of in-use research equipment in shared-access locations, by system purchase price, field, and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	System purchase price (percent of systems in shared-access locations)[2]							
	Total		$10,000-$24,999		$25,000-$74,999		$75,000-$999,999	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	41%	44%	36%	39%	44%	46%	60%	66%
FIELD								
Engineering	50	51	48	49	50	50	60	62
Chemical	26	24	26	22	23	25	33	33
Civil	**	66	**	65	**	64	**	73
Electrical	33	50	30	46	31	48	55	73
Mechanical	57	51	56	46	60	54	46	62
Metallurgical/materials	45	65	37	66	48	65	74	59
Other, n.e.c.	70	50	69	50	73	47	73	58
Agricultural sciences	36	44	37	44	34	44	54	59
Agronomic sciences	31	43	30	42	30	43	55	51
Animal sciences	**	38	**	36	**	41	**	100
Natural resources management	**	**	**	**	**	**	**	**
Biological sciences	36	39	32	35	40	41	64	71
In medical schools	36	39	32	35	41	43	61	68
In colleges/universities	35	38	31	34	38	40	70	74
Computer science	80	63	87	63	68	56	90	89
Environmental sciences	48	49	42	47	54	50	55	55
Materials sciences	81	77	80	67	82	81	82	95
Physical sciences	35	36	27	29	38	37	54	61
Chemistry	38	37	29	29	40	38	66	66
Physics/astronomy	31	34	25	30	36	35	38	53
Interdisciplinary, n.e.c.	**	94	**	92	**	96	**	99
INSTITUTION TYPE								
Colleges/universities	42	45	38	41	45	46	60	66
Private	40	35	36	31	39	34	60	56
Public	44	49	39	44	48	52	60	71
Top 20 in R&D	42	46	38	41	43	49	63	69
Not in top 20	43	44	38	40	46	45	58	65
Medical schools	36	39	32	36	41	43	60	67

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Shared-access locations are locations other than within-department laboratories of principal investigators.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-24. Function of in-use research equipment, by research field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	System function (percent of systems)			
		Dedicated[2]		General purpose	
		1982-83	1985-86	1982-83	1985-86
Total	100%	27%	31%	73%	69%
FIELD					
Engineering	100	37	41	63	59
Chemical	100	52	53	48	47
Civil	100	**	25	**	75
Electrical	100	44	37	56	63
Mechanical	100	44	40	56	60
Metallurgical/materials	100	31	52	69	48
Other, n.e.c	100	27	45	73	55
Agricultural sciences	100	24	23	76	77
Agronomic sciences	100	25	23	75	77
Animal sciences	100	**	11	**	89
Natural resources management	100	**	**	**	**
Biological sciences	100	17	19	83	81
In medical schools	100	19	22	81	78
In colleges/universities	100	14	15	86	85
Computer science	100	17	28	83	72
Environmental sciences	100	33	42	67	58
Materials science	100	21	23	79	77
Physical sciences	100	39	42	61	58
Chemistry	100	31	35	69	65
Physics/astronomy	100	48	51	52	49
Interdisciplinary, n.e.c	100	**	48	**	52
INSTITUTION TYPE					
Colleges/universities	100	30	33	70	67
Private	100	33	36	67	64
Public	100	29	32	71	68
Top 20 in R&D	100	31	31	69	69
Not in top 20	100	29	34	71	66
Medical schools	100	19	22	81	78

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Dedicated for use in a specific experiment, or series of experiments.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-25. Types of users of in-use research equipment, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Percent of systems used by:[2]									
	Faculty, this department/ installation		Graduate students and post-doctorates this department/ installation		Researchers from other departments of this university[3]		Researchers from other universities[3]		Nonacademic researchers	
	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total	92%	90%	84%	82%	34%	30%	12%	11%	12%	12%
FIELD										
Engineering	90	85	80	78	28	27	7	7	11	9
Chemical	78	71	79	86	26	19	5	2	2	1
Civil	**	94	**	71	**	17	**	5	**	7
Electrical	89	85	90	73	40	27	15	8	7	8
Mechanical	96	88	94	88	23	22	3	5	7	17
Metallurgical/materials	92	83	83	76	30	36	7	4	6	3
Other, n.e.c.	92	85	57	76	22	37	7	15	28	13
Agricultural sciences	94	96	84	84	46	36	6	5	10	7
Agronomic sciences	95	96	81	84	44	36	8	6	11	6
Animal sciences	**	97	**	85	**	40	**	2	**	2
Natural resources management	**	**	**	**	**	**	**	**	**	**
Biological sciences	95	93	85	84	36	35	9	10	13	12
In medical schools	95	94	84	84	38	37	9	12	13	12
In colleges/universities	95	92	87	84	34	34	9	8	13	12
Computer science	90	88	90	80	54	31	10	3	9	8
Environmental sciences	92	95	81	74	29	23	31	21	18	12
Materials science	64	81	66	76	57	43	8	7	13	9
Physical sciences	89	87	89	86	28	24	19	17	9	12
Chemistry	88	83	91	86	30	27	20	13	10	9
Physics/astronomy	91	92	86	85	26	20	17	23	8	16
Interdisciplinary, n.e.c.	**	77	**	55	**	23	**	7	**	60
INSTITUTION TYPE										
Colleges/universities	91	89	85	81	32	28	13	11	11	12
Private	90	86	86	82	31	28	16	14	10	10
Public	91	89	84	81	33	29	12	10	12	13
Top 20 in R&D	87	87	87	86	36	30	12	11	13	10
Not in top 20	93	89	83	79	30	27	13	11	10	13
Medical schools	95	94	84	84	38	37	10	12	13	12

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Entries indicate percent of active research instrument systems used for research by at least one person in the category specified. More than one category may apply for a given system.

[3]Entries include faculty, post-doctorate, and graduate/medical student users.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-25a. Types of users of in-use research equipment, by system purchase price and research status: National estimates, 1982-83 and 1985-86[1]

System purchase price and system research status	Percent of systems used by:[2]									
	Faculty, this department/ installation		Graduate students and post-doctorates this department/ installation		Researchers from other departments of this university[3]		Researchers from other universities[3]		Nonacademic researchers	
	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total, selected fields	92%	90%	84%	82%	34%	30%	12%	11%	12%	12%
PURCHASE PRICE										
$10,000 - $24,999	91	90	85	82	31	26	8	8	9	10
$25,000 - $74,999	92	89	83	81	35	33	15	13	13	14
$75,000 - $999,999	95	92	87	85	49	48	31	29	22	20
RESEARCH STATUS										
State-of-the-art systems	94	92	82	83	30	28	15	15	15	14
Other systems	91	89	85	82	35	31	12	10	11	11

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Entries indicate percent of active research instrument systems used for research by at least one person in the category specified. More than one category may apply for a given system.

[3]Entries include faculty, post-doctorate, and graduate/medical student users.

SOURCE: National Science Foundation, SRS

Table B-26. Mean annual number of users per system for in-use research equipment, by system, function, field, and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	System function (mean annual number of users per system)					
	Total		General purpose		Dedicated[2]	
	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total	13.9	14.2	16.1	17.0	8.2	7.9
FIELD						
Engineering	13.0	14.0	14.9	18.3	9.8	8.1
Chemical	6.4	8.5	9.6	12.7	3.6	4.9
Civil	**	10.5	**	10.8	**	9.7
Electrical	20.6	18.9	23.2	25.9	17.6	7.0
Mechanical	8.8	10.8	12.0	14.5	5.0	5.6
Metallurgical/materials	11.0	12.6	12.7	18.8	7.0	6.8
Other, n.e.c.	13.1	15.6	13.5	17.1	12.2	14.1
Agricultural sciences	11.0	10.8	12.0	11.1	6.9	8.4
Agronomic sciences	10.0	11.3	10.7	11.2	6.9	9.9
Animal sciences	**	9.6	**	10.0	**	6.5
Natural resources management	**	**	**	**	**	**
Biological sciences	11.4	11.6	12.4	12.8	7.0	6.4
In medical schools	10.8	11.2	11.8	12.6	6.6	6.3
In colleges/universities	12.4	12.0	13.1	13.0	7.7	6.7
Computer science	48.6	46.4	53.9	56.8	21.4	19.8
Environmental sciences	12.4	11.2	15.3	13.6	6.5	7.9
Materials science	24.5	19.1	27.5	22.7	12.3	7.0
Physical sciences	15.4	14.7	20.4	19.8	7.7	7.7
Chemistry	18.9	15.5	23.6	20.3	8.7	6.4
Physics/astronomy	11.1	13.6	15.2	18.9	6.8	8.8
Interdisciplinary, n.e.c.	**	12.0	**	17.5	**	6.7
INSTITUTION TYPE						
Colleges/universities	14.9	15.0	17.7	18.4	8.6	8.2
Private	17.5	15.5	21.8	19.8	9.1	7.9
Public	13.6	14.8	15.8	17.9	8.3	8.3
Top 20 in R&D	18.7	17.0	22.3	20.4	11.0	9.7
Not in top 20	12.8	14.0	15.1	17.4	7.1	7.5
Medical schools	10.8	11.2	11.8	12.6	6.5	6.3

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]Dedicated for use in a specific experiment, or series of experiments.

**Unstable estimate: base is less than 500 systems.

RCE: National Science Foundation, SRS

Table B-26a. Mean annual number of users per system for in-use research equipment, by system function, and by other system characteristics: National estimates, 1982-83 and 1985-86[1]

System characteristics	System function (mean annual number of users per system)					
	Total		General purpose		Dedicated[2]	
	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total, selected fields	13.9	14.2	16.1	17.0	8.2	7.9
RESEARCH STATUS						
State-of-the-art	13.0	13.1	15.1	15.5	8.6	9.3
Other systems in research use	14.2	14.5	16.3	17.4	8.1	7.3
PURCHASE PRICE						
$10,000 - $24,999	12.1	12.1	13.7	14.0	7.6	7.7
$25,000 - $74,999	13.8	14.6	16.4	18.2	8.0	7.5
$75,000 - $999,999	25.6	26.7	30.4	31.7	12.8	11.0
AGE						
Under 3 years	15.7	15.5	19.1	19.3	8.8	8.5
3 - 5 years	13.9	14.5	15.8	18.1	9.0	7.1
6 - 8 years	12.8	13.7	14.4	15.4	7.2	9.4
Over 8 years	11.8	11.4	13.4	13.1	6.2	6.2
CONDITION						
Excellent	14.4	14.5	16.7	17.4	8.8	8.6
Average	13.3	14.0	15.1	17.0	7.8	6.9
Poor	13.4	12.1	16.6	14.1	6.0	6.6
LOCATION						
Within department lab of principal investigator	8.9	9.0	9.9	10.5	7.1	6.5
Shared-access location	21.2	20.9	22.7	23.4	12.7	11.3

[1]For the agricultural, biological and environmental services, estimates are for FY 1986 and FY 1983. In all other fields, estimates are for FY 1985 and FY 1982.

[2]Dedicated for use in a specific experiment, or series of experiments.

SOURCE: National Science Foundation, SRS.

Table B-27. Principal means of maintenance and repair of in-use research equipment, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	Principal means of servicing (percent of systems)[2]											
		Service contract		Field service		University M/R personnel		Research personnel		Warranty/ Other		No servicing was required	
		1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
Total	100%	24%	24%	24%	21%	18%	14%	15%	11%	2%	4%	18%	26%
FIELD													
Engineering	100	12	15	20	19	25	16	20	11	2	2	20	38
Chemical	100	9	9	29	25	14	17	26	17	4	4	19	28
Civil	100	**	16	**	18	**	14	**	9	**	1	**	42
Electrical	100	13	14	19	11	25	19	26	15	4	2	13	39
Mechanical	100	11	16	21	14	23	16	9	9	1	2	34	43
Metallurgical/materials	100	11	11	24	31	21	7	20	12	1	3	23	36
Other, n.e.c.	100	11	19	14	23	34	17	26	6	2	1	13	34
Agricultural sciences	100	23	17	30	29	12	15	10	12	3	5	22	22
Agronomic sciences	100	19	16	32	30	11	13	12	12	4	7	22	22
Animal sciences	100	**	24	**	27	**	14	**	13	**	4	**	18
Natural resources management	100	**	**	**	**	**	**	**	**	**	**	**	**
Biological sciences	100	38	36	25	23	10	9	8	6	2	5	17	21
In medical schools	100	39	37	25	23	8	7	8	6	2	5	17	22
In colleges/universities	100	37	35	25	23	11	10	8	7	2	5	17	20
Computer science	100	53	49	25	12	11	16	3	1	0	7	8	15
Environmental sciences	100	14	15	20	22	28	20	18	16	2	3	19	24
Materials science	100	21	10	19	23	20	18	28	17	0	3	12	30
Physical sciences	100	8	13	24	17	27	20	22	20	2	2	17	28
Chemistry	100	9	10	28	20	29	24	17	19	3	2	14	26
Physics/astronomy	100	7	17	19	13	25	14	28	21	1	3	21	31
Interdisciplinary, n.e.c	100	**	9	**	30	**	32	**	5	**	7	**	17
INSTITUTION TYPE													
Colleges/universities	100	19	21	23	20	21	16	17	12	2	3	18	27
Private	100	22	26	25	19	18	10	14	14	2	4	19	28
Public	100	17	19	22	21	23	19	18	12	2	3	17	26
Top 20 in R&D	100	18	20	23	20	22	18	17	11	2	3	19	28
Not in top 20	100	19	21	23	21	21	15	17	13	2	4	17	26
Medical schools	100	39	37	25	23	8	7	9	6	2	5	17	22

[1] For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2] If more than one means of servicing was used during the reference year, the system was assigned to the left-most category that applied.

**Unstable estimate: base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-27a. Principal means of maintenance and repair of in-use research equipment, by selected system characteristics: National estimates, 1982-83 and 1985-86[1]

System characteristics	Total	Principal means of servicing (percent of systems)[2]											
		Service contract		Field service		University M/R personnel		Research personnel		Warranty/ Other		No servicing was required	
		1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86	1982 -83	1985 -86
T[illegible]lected fields	100%	24%	24%	24%	26%	18%	15%	15%	13%	2%	6%	18%	15%
RESEARCH STATUS													
State-of-the-art	100	22	20	22	26	14	11	16	11	4	11	22	20
Other systems in research use	100	24	26	24	26	19	17	14	13	1	4	16	14
PURCHASE PRICE													
$10,000 - $24,999	100	22	21	24	28	17	15	14	12	2	6	21	18
$25,000 - $74,999	100	23	27	23	25	19	16	18	15	2	6	14	12
$75,000 - $999,999	100	35	39	24	21	23	18	11	11	2	5	5	6
AGE													
Under 3 years	100	23	23	24	22	14	10	12	11	4	13	24	20
3 - 5 years	100	26	25	26	29	15	16	15	13	2	1	17	16
6 - 8 years	100	27	24	28	33	19	18	15	14	0	1	10	10
Over 8 years	100	20	26	20	26	27	22	18	15	0	1	14	10
CONDITION													
Excellent	100	24	25	21	24	15	14	13	11	2	7	24	19
Average	100	25	25	26	29	19	16	16	14	2	3	12	13
Poor	100	16	21	28	33	31	24	20	16	2	3	3	4
LOCATION													
Within-department lab of principal investigator	100	20	21	25	28	15	13	16	15	2	6	21	17
Shared-access location	100	29	28	21	24	22	19	13	10	2	5	13	13

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]If more than one means of servicing was used during the reference year, the system was assigned to the left-most category that applied.

SOURCE: National Science Foundation, SRS

Table B-28. Annual expenditures for maintenance and repair of in-use research equipment, by principal means of servicing, field, and institution type: National estimates, 1985-86 and percent change from 1982-83 (inflation-adjusted)[1]

Field and institution type	Principal means of servicing (annual expenditures; dollars in millions)[2]							
	Total		Service contract		Field service		All other means	
	1985-86	Percent Change[3]	1985-86	Percent Change[3]	1985-86	Percent Change[3]	1985-86	Percent Change[3]
Total	$79.03	41%	$48 28	67%	$14 51	13%	$16 24	12%
FIELD								
Engineering	16.25	70	8 57	104	2.69	25	4 99	56
Chemical	1.55	132	0.25	33	0.42	128	0 88	207
Civil	0.89	**	0.51	**	0.23	**	0 16	**
Electrical	4 33	68	2.71	145	0.62	8	0 99	10
Mechanical	2 85	41	1.89	66	0 35	65	0 61	9
Metallurgical/materials	1.18	-22	-21	38	0 39	-49	0.21	-42
Other, n.e.c.	5.45	142	2 60	136	0.70	90	2.15	176
Agricultural sciences	1 65	12	0.76	11	0.42	-22	0 47	89
Agronomic sciences	1.08	22	0.47	42	0.27	-29	0.34	95
Animal sciences	0.34	**	0 21	**	0.07	**	0.05	**
Natural resources management	0 23	**	0.08	**	0 08	**	0 07	**
Biological sciences	23.12	32	18.17	39	3.10	13	1 85	10
In medical school	12.75	17	10.25	22	1.60	0	0.91	0
In colleges/universities	10.36	58	7.92	69	1.50	32	0.94	24
Computer science	7 61	111	6 86	116	0.39	77	0 37	69
Environmental sciences	6 31	37	3.56	88	1 23	8	1 51	-3
Materials science	1.59	-9	0.65	3	0 64	263	0 30	-68
Physical sciences	20.95	22	8 78	88	5.67	-2	6.49	-1
Chemistry	10.50	23	3.56	64	3 52	4	3 43	16
Physics/astronomy	10 45	22	5.23	110	2.15	-11	3 07	-15
Interdisciplinary, n e c.	1.55	**	0.93	**	0 37	**	0 25	**
INSTITUTION TYPE								
Colleges/universities	64 84	46	37.78	87	12 75	14	15 31	12
Private	21.37	27	13 27	47	4 21	18	3.89	-8
Public	44.47	58	24.51	120	8.54	12	11.42	21
Top 20 in R&D	22.14	30	12.85	65	4 02	8	5 27	-4
Not in top 20	43 71	56	24.93	102	8.74	17	10.04	24
Medical schools	13.19	19	10 50	23	1.75	10	0 93	1

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]If more than one means of servicing was used during the reference year, the system was assigned to the left-most category that applied.

[3]Estimates are adjusted for inflation. For procedure, see Appendix F.

**Unstable estimate: 1982-83 base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-28a. Annual expenditures for maintenance and repair of in-use research equipment, by principal means of servicing, field, and institution type: National estimates, 1982-83 and 1985-86 (inflation-adjusted)[1]

Field and institution type	Principal means of servicing (annual expenditures; dollars in millions)[2]							
	Total		Service contract		Field service		All other means	
	1982-83	1985-86[3]	1982-83	1985-86[3]	1982-83	1985-86[3]	1982-83	1985-86[3]
Total	$49.97	$70.31	$25.72	$43.05	$11.42	$12.94	$12.84	$14.32
FIELD								
Engineering	8.35	14.23	3.72	7.58	1.91	2.40	2.72	4.24
Chemical	0.58	1.34	0.17	0.23	0.17	0.38	0.24	0.73
Civil	0.43	0.79	0.20	0.45	0.08	0.21	0.15	0.14
Electrical	2.26	3.80	0.97	2.39	0.52	0.56	0.77	0.85
Mechanical	1.78	2.51	1.00	1.66	0.19	0.32	0.59	0.54
Metallurgical/materials	1.34	1.05	0.39	0.55	0.63	0.32	0.32	0.18
Other, n.e.c.	1.95	4.72	0.98	2.31	0.32	0.62	0.65	1.80
Agricultural sciences	1.35	1.52	0.63	0.70	0.49	0.39	0.23	0.43
Agronomic sciences	0.81	0.99	0.30	0.43	0.35	0.25	0.16	0.31
Animal sciences	0.39	0.31	0.26	0.20	0.09	0.07	0.04	0.05
Natural resources management	0.15	0.21	0.06	0.07	0.06	0.07	0.03	0.07
Biological sciences	16.00	21.14	11.98	16.62	2.50	2.84	1.52	1.68
In medical schools	10.06	11.77	7.75	9.46	1.47	1.47	0.84	0.83
In colleges/universities	5.94	9.37	4.22	7.15	1.03	1.36	0.69	0.85
Computer science	3.11	6.56	2.73	5.90	0.19	0.34	0.20	0.33
Environmental sciences	4.14	5.68	1.70	3.21	1.02	1.10	1.42	1.37
Materials science	1.58	1.44	0.57	0.59	0.16	0.58	0.85	0.27
Physical sciences	15.01	18.41	4.06	7.65	5.09	4.99	5.85	5.77
Chemistry	7.51	9.25	1.89	3.09	3.00	3.12	2.62	3.04
Physics/astronomy	7.50	9.16	2.18	4.56	2.10	1.87	3.22	2.73
Interdisciplinary, n.e.c.	0.43	1.33	0.32	0.81	0.05	0.31	0.06	0.21
INSTITUTION TYPE								
Colleges/universities	39.74	58.13	17.81	33.36	9.94	11.32	11.99	13.46
Private	14.92	18.99	8.04	11.81	3.16	3.75	3.72	3.44
Public	24.82	39.14	9.77	21.55	6.77	7.57	8.27	10.03
Top 20 in R&D	15.48	20.18	7.10	11.73	3.39	3.67	4.98	4.78
Not in top 20	24.27	37.95	10.71	21.63	6.55	7.65	7.01	8.68
Medical schools	10.23	12.17	7.90	9.70	1.48	1.62	0.85	0.85

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]If more than one means of servicing was used during the reference year, the system was assigned to the left-most category that applied.

[3]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Table B-29. Mean annual expenditures per institution for maintenance and repair of in-use research equipment, by principal means of servicing, field, and institution type: National estimates, 1985-86 and percent change from 1982-83[1]

Field and institution type	Principal means of servicing (mean annual expenditures per institution, dollars in thousands)[2]							
	Total		Service contract		Field service		All other means	
	1985-86	Percent change[3]	1985-86	Percent change[3]	1985-86	Percent change[3]	1985-86	Percent change[3]
Total	$296.5	36%	$181.5	62%	$54 5	10%	$60 5	7%
FIELD								
Engineering	93 4	62	49 3	94	15 5	19	28 7	49
Chemical	8 9	121	1 4	26	2.4	117	5 0	192
Civil	5.1	**	2.9	**	1.3	**	0 9	**
Electrical	24.9	60	15.6	133	3 6	2	5 7	5
Mechanical	16.4	34	10.9	58	2 0	57	3 5	-13
Metallurgical/materials	6 8	-25	3 5	32	2 1	-51	1.2	-45
Other, n.e.c.	31 3	130	14.9	124	4 0	81	12 3	162
Agricultural sciences	9 4	6	4.4	6	2 4	-25	2 6	76
Agronomic sciences	[illegible]	15	2.7	35	1.6	-32	2 0	80
Animal sciences	1.9	**	1.2	**	0.4	**	0 3	**
Natural resources management	1.3	**	0.5	**	0 5	**	0 4	**
Biological sciences	86.5	27	38 3	34	11.6	10	6 6	[illegible]
In medical schools	138 2	17	111.4	22	17 3	0	9 5	-5
In colleges/universities	59.2	49	45.5	61	8 6	26	5 0	10
Computer science	43.8	100	39.4	105	2.2	68	2 1	61
Environmental sciences	36 1	30	20 5	79	7.1	3	8 6	-9
Materials science	9 2	-14	3 7	[illegible]	3 7	245	1 7	-69
Physical sciences	120.3	17	50 5	79	32.6	-7	37 2	-6
Chemistry	60.3	17	20.4	56	20 2	-1	19 6	10
Physics/astronomy	60.0	16	30 0	99	12.4	-15	17 6	-19
Interdisciplinary, n e.c.	8.9	**	5.4	**	2 1	**	1 5	**
INSTITUTION TYPE								
Colleges/universities	377 7	39	217.1	78	73 3	8	87 3	6
Private	380.7	27	237.0	47	75 2	18	68 5	-9
Public	376 3	46	207.7	105	72 4	4	96 2	[illegible]
Top 20 in R&D	1,103.4	30	642.7	65	200 9	8	259 8	-5
Not in top 20	283.5	47	161.9	91	56.7	10	64 9	16
Medical schools	[illegible]	19	114.2	23	19 1	10	9 7	-3

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In ail other fields, estimates are for 1985 and 1982.

[2]If more than one means of servicing was used during the reference year, the system was assigned to the left-most category that applied.

[3]Estimates are adjusted for inflation. For procedure, see Appendix F.

**Unstable estimate: 1982-83 base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-29a. Mean annual expenditures per institution for maintenance and repair of in-use research equipment, by principal means of servicing, field, and institution type: National estimates, 1982-83 and 1985-86 (inflation-adjusted)[1]

Field and institution type	Principal means of servicing (mean annual expenditures per institution, dollars in thousands)[2]							
	Total		Service contract		Field service		All other means	
	1982-83	1985-86[3]	1982-83	1985-86[3]	1982-83	1985-86[3]	1982-83	1985-86[3]
Total	$202.3	$275.2	$104.1	$168.8	$46.2	$50.7	$52.0	$55.6
FIELD								
Engineering	53.9	87.3	24.0	46.5	12.4	14.7	17.5	26.0
Chemical	3.7	8.2	1.1	1.4	1.1	2.4	1.5	4.5
Civil	2.8	4.9	1.3	2.8	0.5	1.3	0.9	0.9
Electrical	14.6	23.3	6.3	14.7	3.4	3.4	5.0	5.2
Mechanical	11.5	15.4	6.4	10.2	1.2	1.9	3.8	3.3
Metallurgical/materials	8.7	6.5	2.5	3.4	4.0	2.0	2.1	1.1
Other, n.e.c.	12.6	29.0	6.3	14.2	2.1	3.8	4.2	11.0
Agricultural sciences	8.7	9.2	4.1	4.3	3.2	2.4	1.5	2.6
Agronomic sciences	5.2	6.0	2.0	2.6	2.3	1.5	1.0	1.9
Animal sciences	2.5	1.9	1.7	1.2	0.6	0.4	0.2	0.3
Natural resources management	1.0	1.3	0.4	0.5	0.4	0.4	0.2	0.4
Biological sciences	64.8	82.6	48.5	65.2	10.1	11.1	6.2	6.3
In medical schools	109.3	127.6	84.3	102.9	16.0	16.0	9.1	8.7
In colleges/universities	38.3	57.1	27.3	43.9	3.6	8.4	4.4	4.9
Computer science	20.1	40.3	17.6	36.2	1.2	2.1	1.3	2.0
Environmental sciences	26.7	34.7	11.0	19.7	6.6	6.7	9.1	8.3
Materials science	10.2	8.8	[illegible].7	3.6	1.0	3.5	5.5	1.7
Physical sciences	96.8	112.9	26.2	46.9	32.9	30.6	37.7	35.3
Chemistry	48.4	56.6	12.2	18.9	19.3	19.2	16.9	18.5
Physics/astronomy	48.4	56.2	14.0	28.0	13.5	11.5	20.8	16.8
Interdisciplinary, n.e.c.	2.8	8.1	2.1	5.0	0.3	1.9	0.4	1.3
INSTITUTION TYPE								
Colleges/universities	256.4	356.0	114.9	204.6	64.1	69.4	77.4	82.0
Private	292.8	371.5	157.6	231.5	62.0	73.5	72.9	66.6
Public	238.7	349.0	94.0	192.4	65.1	67.6	79.5	89.0
Top 20 in R&D	773.8	1,006.1	355.1	586.5	169.4	183.4	249.2	236.2
Not in top 20	179.7	265.1	79.3	151.2	48.5	53.5	51.9	60.4
Medical schools	111.2	131.9	85.9	105.4	16.1	17.6	9.2	8.9

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]If more than one means of servicing was used during the reference year, the system was assigned to the left-most category that applied.

[3]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Table B-30. Mean annual expenditures per system for maintenance and repair of in-use research equipment, by principal means of servicing, field, and institution type: National estimates, 1985-86 and percent change from 1982-83[1]

Field and institution type	Principal means of servicing (mean annual expenditures per system; dollars in thousands)[2]							
	Total		Service contract		Field service		All other means	
	1985-86	Percent change[3]	1985-86	Percent change[3]	1985-86	Percent change[3]	1985-86	Percent change[3]
Total	$2.1	10%	$3.9	13%	$1.4	-9%	$1.1	-5%
FIELD								
Engineering	2.9	70	6.5	24	1.6	2	2.0	107
Chemical	2.3	89	3.1	-6	1.8	83	2.5	160
Civil	1.7	**	3.5	**	1.4	**	0.7	**
Electrical	3.0	58	8.2	53	2.2	10	1.2	15
Mechanical	3.0	27	6.6	-28	1.4	94	1.4	-4
Metallurgical/materials	1.7	-6	5.0	35	1.1	-59	0.8	-9
Other, n.e.c.	4.4	215	7.5	42	1.6	2	4.9	>500
Agricultural sciences	0.9	-25	1.9	4	0.6	-46	0.6	-3
Agronomic sciences	0.9	-21	1.9	10	0.6	-50	0.6	5
Animal sciences	0.9	**	1.9	**	0.5	**	0.4	**
Natural resources management	0.9	**	2.0	**	0.9	**	0.6	**
Biological sciences	1.5	1	2.5	5	0.7	-9	0.4	-21
In medical school	1.5	-1	2.5	1	0.7	-10	0.5	-19
In colleges/universities	1.4	7	2.4	15	0.7	-7	0.4	-23
Computer science	4.3	-3	6.7	-2	1.5	60	0.8	-56
Environmental sciences	2.7	0	7.3	6	1.9	-31	1.2	-19
Materials science	2.9	-8	8.5	71	3.4	142	1.0	-66
Physical sciences	2.5	2	5.6	-19	2.8	0	1.3	-13
Chemistry	2.1	-1	5.3	0	2.5	0	1.1	-10
Physics/astronomy	3.1	8	5.8	-38	3.4	4	1.6	-10
Interdisciplinary, n.e.c.	1.6	**	8.5	**	1.0	**	0.5	**
INSTITUTION TYPE								
Colleges/universities	2.3	12	4.6	13	1.6	-11	1.2	-4
Private	2.6	9	4.5	-6	2.0	21	1.3	-12
Public	2.1	15	4.6	28	1.5	-23	1.2	0
Top 20 in R&D	2.2	-1	4.6	-4	1.5	-14	1.2	-19
Not in top 20	2.3	20	4.6	23	1.7	-10	1.2	7
Medical schools	1.6	1	2.6	1	0.8	-2	0.5	-18

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2]If more than one means of servicing was used during the reference year, the system was assigned to the left-most category that applied.

[3]Estimates are adjusted for inflation. For procedure, see Appendix F.

**Unstable estimate: 1982-83 base is less than 500 systems.

SOURCE: National Science Foundation, SRS

Table B-30a. Mean annual expenditures per system for maintenance and repair of in-use research equipment, by principal means of servicing, field, and institution type: National estimates, 1982-83 and 1985-86 (inflation-adjusted)[1]

Field and institution type	Principal means of servicing (mean annual expenditures per system; dollars in thousands)[2]							
	Total		Service contract		Field service		All other means	
	1982-83	1985-86[3]	1982-83	1985-86[3]	1982-83	1985-86[3]	1982-83	1985-86[3]
Total	$1 8	$1 9	$3.2	$3 6	$1.4	$1.3	$1.1	$1 0
FIELD								
Engineering	1 6	2 7	4 9	6 1	1.4	1 4	0 9	1 8
Chemical	1 1	2 0	3.0	2.8	0.9	1.6	0 8	2 1
Civil	1 4	1 6	2.5	3 2	0.7	1 3	1.3	0 7
Electrical	1 7	2 7	4.9	7.5	1 8	2.0	0.9	1 1
Mechanical	2 1	2 7	8 3	6 0	0.7	1.3	1 3	1 3
Metallurgical/materials	1 7	1 6	3.5	4 7	2.4	1 0	0 7	0 8
Other, n.e.c.	1 3	4 1	5.3	7 5	1.4	1 4	0 6	4 3
Agricultural sciences	1.1	0 8	1 7	1.8	1.0	0 6	0 6	0 6
Agronomic sciences	1 0	0 8	1 6	1.8	1.1	0.5	0 6	0 6
Animal sciences	1 2	0 8	1 9	1.8	0.8	0.5	0.6	0 3
Natural resources management	1.1	0 8	1 7	1.8	1.5	0 8	0.5	0.5
Biological sciences	1 3	1 4	2.2	2.3	0.7	0.7	0.5	0.4
In medical school	1.5	1.4	2.4	2.4	0 7	0 6	0.5	0.4
In colleges/universities	1 2	1.3	1 9	2 2	0.7	0 7	0.5	0 4
Computer science	4 0	3 9	6.2	6 1	0.9	1.4	1 6	0 7
Environmental sciences	2.5	2.5	6.4	6.8	2.5	1 7	1 4	1 2
Materials science	2 9	2.6	6.5	7 8	1.3	3 2	2 8	1 0
Physical sciences	2 2	2 3	5 4	5 2	2 6	2 6	1 4	1 2
Chemistry	1 9	1 9	[illegible] 6	4 9	2 3	2 3	1 2	1 0
Physics/astronomy	2 6	2 8	5 7	5 4	3 0	3 1	1 7	1.5
Interdisciplinary, n e c	4 4	1.5	14 6	7.9	2 7	0 9	1 0	0 5
INSTITUTION TYPE								
Colleges/universities	1 9	2 1	3 7	4 2	1 6	1.5	1 1	1 1
Private	2 2	2 4	4 4	4 1	1.5	1 8	1 3	1 2
Public	1 7	2 0	3 3	4 3	1.7	1 3	1 1	1 1
Top 20 in R&D	2 0	2 0	4 4	4 2	1 6	1 3	1 3	1 1
Not in top 20	1 8	2 1	3 4	4 2	1 7	1.5	1 0	1 1
Medical schools	1.5	1.5	2.4	2.4	0 7	0 7	0.5	0 4

[1] For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

[2] If more than one means of servicing was used during the reference year, the system was assigned to the left-most category that applied.

[3] Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Table B-31. Adequacy of the research equipment available to faculty, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Adequacy of available research equipment (percent of departments)						
	Total	Excellent		Adequate		Insufficient	
		1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	100%	11%	11%	54%	54%	36%	35%
FIELD							
Engineering	100	8	5	42	45	50	50
Chemical	100	2	4	49	52	49	43
Civil	100	10	2	47	38	44	60
Electrical	100	20	2	22	40	58	58
Mechanical	100	19	1	27	31	54	68
Metallurgical/materials	100	0	0	50	67	50	33
Other, n.e.c.	100	3	11	48	45	48	45
Agricultural sciences	100	8	6	46	50	46	45
Agronomic sciences	100	4	8	47	46	48	47
Animal sciences	100	14	7	53	60	34	33
Natural resources management	100	5	0	35	45	59	55
Biological sciences	100	14	12	60	60	26	28
In medical schools	100	16	11	68	66	16	24
In colleges/universities	100	13	14	52	53	36	32
Computer science	100	2	13	52	44	45	44
Environmental sciences	100	9	10	64	59	27	31
Materials science	100	24	27	62	65	14	9
Physical sciences	100	4	11	56	56	40	32
Chemistry	100	6	13	45	58	49	29
Physics/astronomy	100	2	10	65	55	33	35
Interdisciplinary, n.e.c.	100	30	50	33	37	37	12
INSTITUTION TYPE							
Colleges/universities	100	9	11	50	50	41	39
Private	100	13	18	55	57	31	25
Public	100	8	9	48	49	45	42
Top 20 in R&D	100	4	12	55	57	40	31
Not in top 20	100	11	11	48	49	41	41
Medical schools	100	16	10	68	66	16	23

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

SOURCE: National Science Foundation, SRS

Table B-32. Adequacy of instrumentation support services, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	Excellent		Adequate		Insufficient		Nonexistent	
		Adequacy of instrumentation support services (percent of departments)							
		1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	100%	11%	10%	39%	42%	36%	34%	13%	14%
FIELD									
Engineering	100	4	7	49	45	42	45	5	3
Chemical	100	2	7	64	57	35	36	0	0
Civil	100	0	0	54	26	43	74	3	0
Electrical	100	8	7	41	39	49	53	3	1
Mechanical	100	6	2	62	41	32	57	0	0
Metallurgical/materials	100	4	9	31	69	61	20	5	2
Other, n.e.c.	100	5	12	43	43	40	38	12	7
Agricultural sciences	100	5	3	26	41	40	31	28	25
Agronomic sciences	100	4	4	29	35	44	44	23	21
Animal sciences	100	4	4	21	48	45	11	31	38
Natural resources management	100	8	2	31	45	26	37	35	16
Biological sciences	100	17	11	34	38	31	32	19	19
In medical schools	100	17	10	34	41	29	32	20	17
In colleges/universities	100	16	12	33	34	33	33	17	21
Computer science	100	3	4	33	60	42	20	22	26
Environmental sciences	100	16	9	42	39	36	39	6	13
Materials science	100	50	27	42	65	9	9	0	0
Physical sciences	100	11	16	42	49	41	29	6	7
Chemistry	100	3	12	31	31	54	43	12	14
Physics/astronomy	100	17	19	52	65	30	15	1	0
Interdisciplinary, n.e.c.	100	7	26	75	47	18	18	0	9
INSTITUTION TYPE									
Colleges/universities	100	10	10	41	43	38	35	12	13
Private	100	17	16	34	52	40	22	10	11
Public	100	7	8	43	49	37	38	12	13
Top 20 in R&D	100	8	14	45	41	33	34	14	12
Not in top 20	100	10	9	39	43	39	35	11	13
Medical schools	100	17	10	34	41	28	32	20	17

[1]For the agricultural, biological and environmental sciences, estimates are for 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

SOURCE: National Science Foundation, SRS

Table B-33. Recommendations for increased Federal funding, by field and institution type: National estimates, 1982-83 and 1985-86[1]

Field and institution type	Total	Systems in $50,000-$1,000,000 range		Systems in $10,000-$50,000 range		Lab equipment under $10,000		Other	
		1982-83	1985-86	1982-83	1985-86	1982-83	1985-86	1982-83	1985-86
Total	100%	26%	35%	61%	55%	10%	7%	3%	3%
FIELD									
Engineering	100	28	29	60	59	9	9	3	4
Chemical	100	10	29	70	51	20	20	0	0
Civil	100	6	26	88	47	0	19	5	8
Electrical	100	52	56	23	38	15	2	10	4
Mechanical	100	26	6	67	84	0	0	6	10
Metallurgical/materials	100	62	55	32	39	6	0	0	6
Other, n.e.c.	100	30	18	59	73	10	8	1	1
Agricultural sciences	100	6	18	79	68	15	13	0	0
Agronomic sciences	100	8	20	80	72	12	8	0	1
Animal sciences	100	2	8	82	66	16	26	0	0
Natural resources management	100	10	28	72	65	18	7	0	0
Biological sciences	100	20	35	66	57	13	7	2	2
In medical schools	100	19	43	69	48	10	7	2	2
In colleges/universities	100	20	26	63	66	15	7	1	1
Computer science	100	26	24	74	66	0	3	0	6
Environmental sciences	100	36	43	54	42	2	10	7	5
Materials science	100	83	100	17	0	0	0	0	0
Physical sciences	100	43	53	44	40	6	4	7	2
Chemistry	100	54	65	39	33	6	1	1	1
Physics/astronomy	100	33	42	48	47	7	8	13	3
Interdisciplinary, n.e.c.	100	49	46	44	46	7	1	0	8
INSTITUTION TYPE									
Colleges/universities	100	28	33	59	57	10	8	3	3
Private	100	37	36	54	55	7	7	2	2
Public	100	25	32	61	57	10	8	4	3
Top 20 in R&D	100	32	38	55	51	8	5	4	5
Not in top 20	100	27	31	61	58	10	8	3	2
Medical schools	100	19	44	69	47	10	7	2	2

Top priority for increased Federal instrumentation funding (percent of departments)

[1]For the agricultural, biological and environmental sciences, estimates are for the 1986 and 1983. In all other fields, estimates are for 1985 and 1982.

SOURCE: National Science Foundation, SRS

Table B-34. Annual instrumentation-related expenditures, by kind, field, and institution type: National estimates, FY 1985-86 and percent change from FY 1982-83[1]

Field and institution type	Annual expenditures (dollars in millions)							
	Total		Research equipment		Research-related computer services		Maintenance/repair of research equipment	
	FY 1985-86	Percent change[2]	FY 1985-86	Percent change[2]	FY 1985-86	Percent change[2]	FY 1985-86	Percent change[2]
Total	$908	27%	$687	48%	$74	-45%	$146	25%
FIELD								
Engineering	217	32	164	70	23	-51	29	41
Chemical	22	-4	17	51	2	-75	3	-8
Civil	17	-12	12	-4	3	-47	2	34
Electrical	59	15	47	35	4	-64	8	56
Mechanical	32	49	23	164	5	-51	5	49
Metallurgical/materials	21	90	18	115	1	3	2	19
Other, n.e.c.	66	74	49	122	8	-20	9	59
Agricultural sciences	45	0	33	7	5	-35	6	17
Agronomic sciences	27	-16	20	-14	2	-50	4	17
Animal sciences	8	45	7	62	1	-20	1	39
Natural resources management	10	40	6	83	2	-7	1	2
Biological sciences	242	14	190	31	10	-67	42	18
In medical schools	127	4	98	13	4	-72	25	24
In colleges/universities	115	30	92	59	6	-62	17	10
Computer science	66	96	47	109	4	-2	15	111
Environmental sciences	71	27	52	38	8	7	11	5
Materials science	10	-24	9	-16	1	11	1	-67
Physical sciences	222	30	167	62	20	-44	35	9
Chemistry	104	27	79	76	9	-61	16	20
Physics/astronomy	119	33	89	51	11	-9	19	2
Interdisciplinary, n.e.c.	35	70	25	62	3	40	7	135
INSTITUTION TYPE								
Colleges/universities	780	32	588	57	70	-42	121	25
Private	255	27	196	47	17	-53	42	32
Public	525	34	392	62	53	-37	79	22
Top 20 in R&D	262	30	201	57	23	-44	38	19
Not in top 20	518	32	387	57	47	-40	83	29
Medical schools	128	4	99	13	4	-72	25	25

[1]For the agricultural, biological and environmental sciences, estimates are for FY 1986 and FY 1983. In all other fields, estimates are for FY 1985 and FY 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundations, SRS

Table B-34a. Annual instrumentation-related expenditures, by kind, field, and institution type: National estimates, FY 1982-83 and FY 1985-86 (inflation-adjusted)[1]

Field and institution type	Annual expenditures (dollars in millions)							
	Total		Research equipment		Research-related computer services		Maintenance/repair of research equipment	
	FY 1982-83	FY 1985-86[2]	FY 1982-83	FY 1985-86[2]	FY 1982-83	FY 1985-86[2]	FY 1982-83	FY 1985-86[2]
Total	$638	$809	$413	$612	$121	$66	$104	$131
FIELD								
Engineering	146	193	86	146	41	20	19	26
Chemical	21	20	10	15	8	2	3	3
Civil	17	15	11	10	5	2	1	2
Electrical	46	53	31	42	10	4	5	7
Mechanical	19	29	8	20	9	4	3	4
Metallurgical/materials	10	19	7	16	1	1	2	2
Other, n.e.c.	33	58	19	42	9	7	5	8
Agricultural sciences	41	41	28	30	7	5	5	6
Agronomic sciences	29	24	21	18	4	2	3	4
Animal sciences	5	8	4	6	1	1	1	1
Natural resources management	6	9	3	6	2	2	1	1
Biological sciences	192	220	132	173	28	9	32	38
In medical schools	113	118	81	91	15	4	18	23
In colleges/universities		79	102	52	82	13	5	14
Computer science	29	58	20	41	4	4	6	13
Environmental sciences	49	63	33	46	7	7	9	10
Materials science	12	9	10	8	1	1	2	1
Physical sciences	151	196	91	147	32	18	28	31
Chemistry	71	90	39	68	21	8	12	14
Physics/astronomy	79	105	52	79	11	10	16	17
Interdisciplinary, n.e.c.	18	30	13	21	2	3	3	6
INSTITUTION TYPE								
Colleges/universities	524	691	332	521	106	62	86	108
Private	178	226	117	173	32	15	28	38
Public	346	465	215	348	74	47	58	70
Top 20 in R&D	183	239	117	184	38	21	29	35
Not in top 20	341	451	215	337	69	41	57	73
Medical schools	114	118	81	91	15	4	18	23

[1]For the agricultural, biological and environmental sciences, estimates are for FY 1986 and FY 1983. In all other fields, estimates are for FY 1985 and FY 1982.

[2]Estimates are adjusted for inflation. For procedure, see Appendix F.

SOURCE: National Science Foundation, SRS

Table B-35. Annual expenditures for research equipment as a proportion of total R&D expenditures, by selected fields: National estimates, FY 1982-83 and FY 1985-86[1]

Selected fields	FY 1982-83 R&D expenditures (dollars in millions)			FY 1985-86 R&D expenditures (dollars in millions)		
	Total[2]	Research equipment		Total[2]	Research equipment	
		Amount	Percent		Amount	Percent
Total	$4,925	$390	8%	$6,527	$653	10%
Engineering, total	1,026	86	8	1,383	164	12
Chemical	84	10	12	109	17	16
Civil	109	11	10	146	12	8
Electrical	224	31	14	337	47	14
Mechanical	142	8	6	204	23	11
Other, n.e.c.	467	26	6	587	66	11
Agricultural sciences	896	28	3	1,122	33	3
Biological sciences	1,410	132	9	1,833	190	10
Computer science	149	20	13	278	47	17
Environmental sciences	620	33	5	774	52	7
Physical sciences	824	91	11	1,137	167	15
Chemistry	309	39	13	415	79	19
Physics/astronomy	515	52	10	722	89	12

[1]For the agricultural, biological and environmental sciences, estimates are for FY 1986 and FY 1983. In all other fields, estimates are for FY 1985 and FY 1982.

[2]Source of data for FY 1982-85 is Academic Science/Engineering R&D Funds: Fiscal Year 1985. National Science Foundation, NSF-640, Table B-3. Source of data for FY 1986 is Academic Science/Engineering R&D Funds: Fiscal Year 1986. National Science Foundation, NSF 88-312, Table B-3.

NOTE: Subcategory values may not sum exactly to total because of rounding.

SOURCE: National Science Foundation, SRS

APPENDIX C

DEPARTMENT/FACILITY QUESTIONNAIRE

Form
Number:

OMB No. 3145-0067
Expiration Date 2/28/89

NATIONAL SURVEY OF ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS II

NATIONAL SCIENCE FOUNDATION

DEPARTMENT/FACILITY QUESTIONNAIRE

THIS REPORT IS AUTHORIZED BY LAW (P.L. 96-44). WHILE YOU ARE NOT REQUIRED TO RESPOND, YOUR COOPERATION IS NEEDED TO MAKE THE RESULTS OF THIS SURVEY COMPREHENSIVE, ACCURATE, AND TIMELY. INFORMATION GATHERED IN THIS SURVEY WILL BE USED ONLY FOR DEVELOPING STATISTICAL SUMMARIES. INDIVIDUAL PERSONS, INSTITUTIONS, AND DEPARTMENTS WILL NOT BE IDENTIFIED IN PUBLISHED SUMMARIES OF THE DATA.

BACKGROUND AND INSTRUCTIONS

There is widespread concern about whether academic research scientists and engineers have sufficient access to the kinds of equipment needed to permit continuing research at the frontier of scientific knowledge. To help the National Science Foundation and other Federal agencies set appropriate equipment funding levels and priorities, this congressionally-mandated survey is intended to update findings for a similar study undertaken in 1982-83 and to document trends in (a) the amount, cost, and condition of the scientific research equipment currently available in the nation's principal research universities, and (b) the nature and extent of the need for upgraded or expanded equipment in the major fields of science and engineering.

The update survey is being conducted in two phases. The current phase (Phase I) deals with research equipment in the physical sciences, engineering, and computer sciences. Next year, Phase II will be concerned with the agricultural, biological, and environmental sciences.

This Department Questionnaire seeks a broad overview of equipment-related expenditures and needs in this department (or nondepartmental research facility). Items 1-10 (Parts A and B) are factual in nature and may be delegated to any person or persons who can provide the requested data. In these sections, informed estimates are acceptable whenever precise information is not available from annual reports or other data sources. Items 11-16 (Part C) call for judgmental assessments about equipment-related research needs and priorities of the department (or facility) as a whole and should be answered by the department chairperson (or facility director) or by a designee who is in a position to make such judgments. We urge that particular attention be given to Item 15, which asks for this department's (or facility's) recommendations about needed changes in equipment funding policies and procedures.

This form should be returned to your institution's study coordinator. Your cooperation in returning the survey form promptly is very important.

PART A. DESCRIPTIVE INFORMATION

1. Institution name: ____________________

2. Department (or nondepartmental research facility) name:

____

3. This is: (CHECK ONE)

|_| 1 An academic department (CONTINUE WITH ITEM 4)

|_| 2 A nondepartmental research facility (SKIP TO ITEM 7)

4. Number of doctoral degrees awarded in the 1984-85 academic year to students in this department:

____

5. Number of full-time faculty members in this department: __________

6. Number of full-time faculty members in this department who are participating in ongoing research projects:

____

PART B. RESEARCH-RELATED FUNDING AND EXPENDITURES

7. Department (or facility) expenditures for scientific research equipment during the institution's 1985 fiscal year.

$__________ FY 1985 expenditures for scientific research equipment

NOTE: SCIENTIFIC EQUIPMENT IS ANY ITEM (OR INTERRELATED COLLECTION OF ITEMS COMPRISING A SYSTEM) OF NONEXPENDABLE TANGIBLE PROPERTY OR SOFTWARE, HAVING A USEFUL LIFE OF MORE THAN TWO YEARS AND AN ACQUISITION COST OF $500 OR MORE, WHICH IS USED WHOLLY OR IN PART FOR RESEARCH. INCLUDE ALL SCIENTIFIC RESEARCH EQUIPMENT ACQUIRED FROM ALL SOURCES -- FEDERAL, STATE, INSTITUTIONAL, INDUSTRIAL, ETC.

8. Please provide an approximate breakdown by source of funds for this department's (or facility's) FY 1985 expenditures for scientific research equipment. [NOTE: ENTRIES SHOULD SUM TO 100 PERCENT: ESTIMATES ARE ACCEPTABLE.]

Source of funds	Percent of FY 1985 expenditures for scientific research equipment
a. Federal Government	________%
b. Internal institution funds	________%
c. State equipment or capital development appropriations	________%
d. Private nonprofit foundations/ organizations	________%
e. Business or industry	________%
f. Other (SPECIFY) ________	________%
TOTAL, ALL FUNDING SOURCES	100 %

9. FY 1985 expenditures for purchase of research-related computer services at:

$________ Institution computing facilities

$________ Other computing facilities

10. FY 1985 expenditures for maintenance and repair of all scientific research equipment in this department (or facility):

$________ Service contracts or field service for maintenance and repair of individual instruments

$________ Salaries of institution maintenance/repair personnel (pro-rate if personnel do not work full-time in <u>this</u> department/facility or on servicing of <u>research</u> equipment)

$________ Other direct costs of supplies, equipment and facilities for servicing of research instruments in this department/facility

$________ Total

PART C. ADEQUACY OF AND NEED FOR SCIENTIFIC RESEARCH EQUIPMENT

11. Are the instrumentation support services (e.g., machine shop, electronics shops) at this department or facility: (CHECK ONE)

|__| 1 Excellent

|__| 2 Adequate

|__| 3 Insufficient

|__| 4 Nonexistent

12. In terms of its capability to enable faculty investigators to pursue their major research interests, is the research equipment in this department (or facility) generally:

|__| 1 Excellent

|__| 2 Adequate

|__| 3 Insufficient

13. If greater Federal funding of research equipment were possible, in which single area would increased investment be most beneficial to investigators in this department/facility? (CHECK ONE)

|__| 1 Large scale regional and nati nstrumentation facilities

|__| 2 Major shared access instrument systems ($50,000-$1,000,000) not presently available to department/facility members

|__| 3 Upgrading/expansion of equipment in $10,000-$50,000 range

|__| 4 General enhancement of equipment and supplies in labels of individual P.I.'s (items generally below $10,000)

|__| 5 Other (SPECIFY) ________________________________

____

14. What three items of research equipment in the $10,000-$1,000,000 cost range are the topmost priorities at this time in this department/facility? (Please list in priority order beginning with priority no. 1.)

Item description	Approximate cost
1. ____________________	__________
2. ____________________	__________
3. ____________________	__________

15. How could current Federal equipment funding policies and/or procedures be modified to better meet the research needs of researchers in this department/facility?

____

____

____

16. Please note in the space below: (a) any additional information needed to describe the research equipment and equipment-related needs in this department/facility, or (b) any suggestions to improve this survey questionnaire.

____

____

____

17. Person who prepared this submission:

NAME AND TITLE | AREA CODE - EXCH - NO - EXT

18. How many person-hours were required to complete this form?

HOURS MINUTES

APPENDIX D

INSTRUMENT DATA SHEET (UPDATE)

OMB No. 3145-0067
Expiration Date 2/28/89

NATIONAL SURVEY OF ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS II

NATIONAL SCIENCE FOUNDATION
INSTRUMENT DATA SHEET: UPDATE

The instrument or component shown below was part of a major national assessment of the condition of academic research instrumentation in 1982. Certain elements relating to the instrument's status, condition, and usage need updating as of 1985.

Identifying data for the instrument and some of the information about its cost, acquisition, and configuration that was obtained in 1982 are reproduced below in the space provided. Please review these data and make any necessary changes. Then please complete the form by answering questions 1 through 13. See back pag 'or definitior - of key terms .

We ask that the requested information be obtained from the research investigator or person(s) who is most knowledgeable about the history and current status of the instrument. Where exact cost (or other) data are not available, estimates are acceptable. Your estimates will be better than ours.

This study is authorized by law (P.L. 96-44). While you are not required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate, and timely. Information gathered in this survey will be used only for developing statistical summaries. Individual persons, institutions, and departments will not be identified in published summaries of the data.

Your cooperation in returning the survey form promptly is very important. Please direct any questions about this form to your university study coordinator.

INSTRUMENT DATA: PLEASE REVIEW AND CORRECT AS NEEDED

SURVEY FORM NUMBER.

CORRECTIONS

A. Department or Facility:

B. Preparer of 1982 Survey Form:

C. Instrument: ______

D. Central Records ID: ______

E. Location: ______

F Year of Purchase: ______

G. Instrument Purchase Price: ______

H. Means of Acquisition at this University: ______

I. Source of Funds for Acquisition at this University: ______

J. Does Instrument have any Dedicated Accessories NOT included in Instrument Purchase Price: ______

K. Aggregate Purchase Price of all dedicated Accessories NOT included in Instrument Purchase Price: ______

L. Cost and Description of Separately Purchased Dedicated Accessories Costing $10,000+ (Please indicate additions/deletions since 1982)

1. What was this instrument's status during 1985? (CHECK ONE)

|_| 1 Used in original scientific research (CONTINUE TO ITEM 2)

|_| 2 Used only for nonresearch purposes (SKIP TO ITEM 11)

|_| 3 Inactive or inoperable throughout 1985 (SKIP TO ITEM 11)

|_| 4 No longer exists (cannibalized, junked, traded in, or otherwise disposed of) (SKIP TO ITEM 11)

|_| 5 Not yet in service (SKIP TO ITEM 11)

|_| 6 Other (SPECIFY) ______________________________

2. Where was this instrument located during 1985 when in research use? (CHECK ONE)

|_| 1 National, regional, or interuniversity research instrumentation lab (CONTINUE TO ITEM 3)

|_| 2 Nondepartmental research facility (CONTINUE TO ITEM 3)

|_| 3 Department-managed common lab or research instrumentation facility (CONTINUE TO ITEM 3)

|_| 4 Within-department research lab of principal investigator (CONTINUE TO ITEM 3)

|_| 5 Lab or facility used almost exclusively for undergraduate instruction, or for other nonresearch activity (SKIP TO ITEM 11)

|_| 6 Other (SPECIFY)______________________________

3. What was the instrument's principal field of research use in 1985? (e.g., physics, astronomy, chemistry, computer science, electrical engineering)

____

____

4. How much was spent for maintenance and repair (not for operation) of this instrument and its accessories in 1985?

$________

5. Means of servicing (maintenance/repair) this instrument during 1985: (CHECK ALL THAT APPLY)

|_| 1 None required

|_| 2 Service contract

|_| 3 Field service, as needed

|_| 4 Institution-employed maintenance/repair staff

|_| 5 Research personnel (faculty, students, post-docs)

|_| 6 Other (SPECIFY):______________

6. Adequacy of the servicing (maintenance/repair) this instrument received during 1985. (CHECK ONE)

|_| 1 Not applicable: no servicing was needed

|_| 2 Excellent

|_| 3 Adequate

|_| 4 Inadequate

7. Instrument's general working condition during 1985: (CHECK ONE)

|_| 1 Excellent

|_| 2 Average

|_| 3 Poor (e.g., unreliable, frequent breakdowns, difficult to maintain or service)

|_| 4 Inoperable entire year

8. Research function of this instrument during 1985: (CHECK ONE)

|_| 1 Most advanced instrument of its kind that is accessible to those who use it in their research

|_| 2 Used for research; more advanced instruments are available to users when needed

|_| 3 Not used for research during 1985

9. Technical capabilities of this instrument (i.e., the base instrument, excluding accessories) (CHECK ONE)

|_| 1 State-of-the-art (most highly developed and scientifically sophisticated instrument of its kind)

|_| 2 Adequate to meet researcher needs

|_| 3 Inadequate for research (PLEASE EXPLAIN): ______________

10. In 1985, was this a general purpose instrument within an area of research or was it dedicated for a particular experiment or series of experiments? (CHECK ONE)

|_| 1 General purpose

|_| 2 Dedicated

11. How many research investigators made use of this instrument for research purposes during 1985? (ESTIMATE APPROXIMATE NUMBER IN EACH APPLICABLE CATEGORY)

_____ 1 Faculty and equivalent nonfaculty researchers, this department/facility

_____ 2 Graduate and medical students and postdoctorates, this department/facility

_____ 3 Faculty and equivalent nonfaculty researchers, other departments, this university

_____ 4 Graduate and medical students and postdoctorates, other departments, this university

_____ 5 Researchers from other universities

_____ 6 Nonacademic researchers

_____ 7 Other (SPECIFY): ______________________________

_____ Total number of research users

12. Please note in space below: (a) Any additional information needed to clarify the nature, function and quality of this instrument, or (b) any suggestions to improve this questionnaire or its instructions.

13. Person who prepared this submission:

______________________________ ______________________________

NAME AND TITLE AREA CODE - EXCH - NO - EXT

14. How many person-hours were required to complete this form? _____ HOURS _____ MINUTES

DEFINITION OF KEY TERMS

INSTRUMENT PURCHASE PRICE (initial value)

The original price of the instrument (or its components, if built locally) at time of original purchase from the manufacturer. Do not include cost of separately purchased accessories; do not subtract any discount (e.g., for trade-in) which may have been received. Please estimate if original records are not available.

YEAR OF PURCHASE

The calendar year when this instrument (or its principal components) was originally purchased from the manufacturer.

DEDICATED ACCESSORIES

Separately acquired "add-ons" to or components of the instrumentation system of which the instrument described below is the principal element. This includes accessories that are presently dedicated solely for use with the reference instrument but are not included in its purchase price (in item G, page 1). Examples: specimen preparation and photographic accessories for a particular electron microscope; oscilloscope, microprocessor, HPLC, or data system accessories for a particular spectrometer; key entry, disc drive, printer or plotter accessories for a particular microcomputer.

APPENDIX E

INSTRUMENT DATA SHEET (NEW)

OMB No. 3145-0067
Expiration Date 2/28/89

NATIONAL SURVEY OF ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS II

NATIONAL SCIENCE FOUNDATION
INSTRUMENT DATA SHEET

This data sheet is part of a major national assessment of the condition of academic research instrumentation. The data sheet concerns a particular instrument selected from university central inventory records as part of a national sample of research instruments in your field. The sampled item is described below.

We ask that the requested information be obtained from the research investigator or person(s) who is most knowledgeable about the history and current status of this instrument. Where exact cost (or other) data are not available, estimates are acceptable. Your estimates will be better than ours.

This study is authorized by law (P.L. 96-44) While you are not required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate, and timely. Information gathered in this survey will be used only for developing statistical summaries. Individual persons, institutions, and departments will not be identified in published summaries of the data.

Your cooperation in returning the survey form promptly is very important. Please direct any questions about this form to your university study coordinator.

DEFINITION OF KEY TERMS

INSTRUMENT PURCHASE PRICE (initial value)

The original price of the instrument (or its components, if built locally) at time of original purchase from the manufacturer. Do not include cost of separately purchased accessories; do not subtract any discount (e.g., for trade-in) which may have been received. Please estimate if original records are not available.

YEAR OF PURCHASE

The calendar year when this instrument (or its principal components) was originally purchased from the manufacturer.

DEDICATED ACCESSORIES

Separately acquired "add-ons" to or components of the instrumentation system of which the instrument described below is the principal element. This includes accessories that are presently dedicated solely for use with the referenced instrument but are not included in its purchase cost (in item G, below). Examples: specimen preparation and photographic accessories for a particular electron microscope; oscilloscope, microprocessor, HPLC, or data system accessories for a particular spectrometer; key entry, disc drive, printer or plotter accessories for a particular microcomputer.

INSTRUMENT DATA: PLEASE REVIEW AND CORRECT AS NEEDED

	CORRECTIONS
A. SURVEY FORM NUMBER	
B Department or Facility	
C Instrument:	______________
D Central Records ID	______________
E Location.	______________
F Year of Purchase	______________
G Instrument Purchase Price	______________

SEE PAGE 1 FOR DEFINITION OF ALL BOLDFACE TERMS

1. What was this instrument's status during 1985? (CHECK ONE)

|_| 1 Used in original scientific research (CONTINUE TO ITEM 2)

|_| 2 Used only for nonresearch purposes (SKIP TO ITEM 15)

|_| 3 Inactive or inoperable throughout 1985 (SKIP TO ITEM 15)

|_| 4 No longer exists (cannibalized, junked, traded in, or otherwise disposed of) (SKIP TO ITEM 15)

|_| 5 Not yet in service (SKIP TO ITEM 15)

|_| 6 Other (SPECIFY) ____________________

2. Where was this instrument located during 1985 when in research use? (CHECK ONE)

|_| 1 National, regional, or interuniversity research instrumentation lab (CONTINUE TO ITEM 3)

|_| 2 Nondepartmental research facility (CONTINUE TO ITEM 3)

|_| 3 Department-managed common lab or research instrumentation facility (CONTINUE TO ITEM 3)

|_| 4 Within-department research lab of principal investigator (CONTINUE TO ITEM 3)

|_| 5 Lab or facility used almost exclusively for undergraduate instruction, or for other nonresearch activity (SKIP TO ITEM 15)

|_| 6 Other (SPECIFY) ____________________

3. Does this instrument have any **DEDICATED ACCESSORIES** not included in the **INSTRUMENT PURCHASE PRICE** (from ID BOX, item G)? (See page 1 definitions of key terms)

|_| 1 Yes → 3a. Estimated aggregate purchase of all **DEDICATED ACCESSORIES** not included in ID BOX item G. $__________

|_| 2 No

3b. Please describe and estimate the purchase price for each separately purchased **DEDICATED ACCESSORY** costing $10,000 or more. (If additional space is needed, continue in Question 14 or attach a separate continuation sheet.)

Description of accessories $10,000 or more	Purchase cost
1. ____________________	$__________
2. ____________________	$__________
3. ____________________	$__________
4. ____________________	$__________

4. What was the instrument's principal field of research use in 1985? (e.g., physics, astronomy, chemistry, computer science, electrical engineering)

5. How was this instrument acquired at this institution? (CHECK ONE)

- |_| 1 Purchased new
- |_| 2 Purchased used
- |_| 3 Locally built (at or for this institution)
- |_| 4 Transferred from another institution, e.g., by incoming faculty member (SKIP TO ITEM 7)
- |_| 5 Government surplus (SKIP TO ITEM 7)
- |_| 6 Donated new (SKIP TO ITEM 7)
- |_| 7 Donated used (SKIP TO ITEM 7)
- |_| 8 Other (SPECIFY): ________________________

6. Source(s) of funds for acquisition of this instrument at this institution. (SPECIFY APPROXIMATE PERCENTAGE CONTRIBUTION FOR EACH APPLICABLE SOURCE.)

Funding contribution (percent)	Funding source
	Federal sources:
______	NSF (National Science Foundation)
______	NIH (National Institutes of Health)
______	DOD (Department of Defense)
______	DOE (Department of Energy)
______	USDA (Department of Agriculture)
______	Other Federal sources (SPECIFY): ____________
	Non-Federal sources:
______	Institution or department funds
______	State grant or appropriation
______	Private nonprofit foundation
______	Business or industry
______	Other (SPECIFY): ____________
100%	Total

7. How much was spent for maintenance and repair (not for operation) of this instrument and its accessories in 1985?

$________

8. Means of servicing (maintenance/repair) this instrument during 1985: (CHECK ALL THAT APPLY)

- |_| 1 None required
- |_| 2 Service contract
- |_| 3 Field service, as needed
- |_| 4 Institution-employed maintenance/repair staff
- |_| 5 Research personnel (faculty, students, post-docs)
- |_| 6 Other (SPECIFY): ____________

9. Adequacy of the servicing (maintenance/repair) this instrument received during 1985: (CHECK ONE)

- |_| 1 Not applicable: no servicing was needed
- |_| 2 Excellent
- |_| 3 Adequate
- |_| 4 Inadequate

10. Instrument's general working condition during 1985: (CHECK ONE)

- |_| 1 Excellent
- |_| 2 Average
- |_| 3 Poor (e.g., unreliable, frequent breakdowns, difficult to maintain or service)
- |_| 4 Inoperable entire year

11. Research function of this instrument during 1985: (CHECK ONE)

- |_| 1 Most advanced instrument of its kind that is accessible to those who use it in their research
- |_| 2 Used for research; more advanced instruments are available to users when needed
- |_| 3 Not used for research during 1985

12. Technical capabilities of this instrument (i.e., the base instrument, excluding accessories) (CHECK ONE)

|_| 1 State-of-the-art (most highly developed and scientifically sophisticated instrument of its kind)

|_| 2 Adequate to meet researcher needs

|_| 3 Inadequate for research (PLEASE EXPLAIN):

____

13. In 1985, was this a general purpose instrument within an area of research or was it dedicated for a particular experiment or series of experiments? (CHECK ONE)

|_| 1 General purpose

|_| 2 Dedicated

14. How many research investigators made use of this instrument for research purposes during 1985: (ESTIMATE APPROXIMATE NUMBER IN EACH APPLICABLE CATEGORY)

_____ 1 Faculty and equivalent nonfaculty researchers, this department/facility

_____ 2 Graduate and medical students and postdoctorates, this department/facility

_____ 3 Faculty and equivalent nonfaculty researchers, other departments, this university

_____ 4 Graduate and medical students and postdoctorates, other departments, this university

_____ 5 Researchers from other universities

_____ 6 Nonacademic researchers

_____ 7 Other (SPECIFY):________________________________

_____ Total number of research users

15. Please note in space below: (a) Any additional information needed to clarify the nature, function and quality of this instrument, or (b) any suggestions to improve this questionnaire or its instructions.

16. Person who prepared this submission:

________________________________ ________________________
NAME AND TITLE AREA CODE - EXCH - NO - EXT

17. How many person-hours were required to complete this form?

_____ _____
HOURS MINUTES

16.

APPENDIX F

INFLATION ADJUSTMENT METHODOLOGY

INFLATION ADJUSTMENT METHODOLOGY

Although the rate of inflation in the years between the original baseline survey and the update has been the lowest in recent history, the fact is that a dollar of investment in academic research instruments in 1982-83 was not the same in real terms as a dollar of investment in 1985-86. This appendix discusses the adjustments that have been made to remove the effects of inflation in comparisons between the 1985-86 update survey data and data obtained in the 1982-83 baseline survey.

There are three separate ways in which inflation affects comparisons between the two surveys:

1. The dollar values of all equipment-related purchases and expenditures that occurred in the interval between the two studies are affected by inflation. To adjust for this effect in comparisons between the two studies, financial data from the 1985-86 study that involve equipment purchases or other expenditures since the 1982-83 study were converted to 1982-83 constant dollars. Specifically, for the Phase I fields (the physical and computer sciences and engineering), expenditures in each of the three years following the baseline study -- 1983, 1984, and 1985 -- were converted to 1982 constant dollars. In the Phase II fields (the agricultural, biological, and environmental sciences), post-baseline expenditures in each of the years 1984, 1985, and 1986 were converted to 1983 constant dollars.

2. Inflation affects the number of colleges and universities that meet the study's requirement of at least $3 million in annual R&D expenditures. Some of the institutions that met this requirement on the basis of actual 1984 R&D expenditures data, which were used to determine the institution universe in the update survey, would not have met the requirement if 1984 expenditures had been measured in terms of 1980 constant dollars (1980 R&D expenditures data were used to define the universe for the baseline study). To adjust for this effect, it was necessary to determine the number of institutions from the 1985-86 study universe that would not have been eligible if 1984 R&D expenditures data had been expressed in 1980 constant dollars and then recompute institution sampling weights to reflect the redefined universe.

3. Inflation affects the numbers of instruments falling within the study's $10,000 to $1 million cost range. Some in-scope instruments that were purchased since the baseline study for prices close to the $10,000 lower limit would be below the limit, and consequently out-of-scope, in 1982-83 constant dollars. Such instruments were excluded in inflation-adjusted comparisons between the two studies. In principle, the 1985-86 sample could also have included some post-baseline purchases that were slightly over the $1 million upper limit (and consequently out-of-scope when unadjusted national estimates for 1985-86 are produced) that should be added back into the data base when inflation-adjusted comparisons are made. As it happens, however, the 1985-86 sample did not contain any instruments in this category, and no adjustment at the upper end of the instrument cost range was needed.

In estimates of change in aggregate dollar amounts of research equipment (from the instrument survey component of this study), all three adjustments apply. For estimates of change in the number of instrument systems (from the instrument survey), adjustment 1 is not applicable, but adjustments 2 and 3 are appropriate. For estimates of change in departments' equipment exependitures (from the department survey), adjustment 3 is not applicable, but adjustments 1 and 2 both apply.

Selection of a Price Index

The first issue involved in making the above adjustments is the choice of the price index to be used for th conversior f dollar values to constant terms (the same year). As indicated in Table F-1 b w, the overall Consumer Price Index of prices paid by urban consumers (the index usually used to . e 'inflation') rose by 11.4 percent between 1982 and 1985. For durables purchases, the measure was 12.3 percent. These are measures of prices paid by individuals for consumption. More relevant to this analysis is the change in the price of produced goods. These indices (producer price indices) are measures of the prices at which manufactured goods are sold. During the period 1982 - 1985, the overall Producer Price Index increased by 3.2 percent.

Table F-1. Trends in major price indices from 1982 to 1985

Index	1982	1985	Percent Change
Overall Consumer Price Index	289.1	322.2	11.45
Consumer Price Index: Durables 241.1	270.7	12.28	
Overall Producer Price Index	299.3	308.8	3.17
Producer Price Index: Durables Manufacturing; Machinery and Equipment	278.7	298.9	7.25

The overall Producer Price Index is, in turn, composed of indices for numerous subcategories of goods from Farm Products to Durable Goods. Of most interest to this analysis is the Producer Price Index for Machinery and Equipment (category 11), which increased 7.2 percent over the period from 1982 to 1985. However, the various subcategories of the Producer Price Index are, in turn, composed of three- and four-digit subcategories of products for which price indices are calculated.

The three-digit categories range from Agricultural Machinery (category 111) through Miscellaneous Machinery (category 119). Of these, the most germane to the current issue are Special Industry Machinery and Equipment (category 116) and Electrical Machinery and Equipment (category 117).* The Special Industry Machinery and Equipment category covers a wide range of different equipment, and the Electrical Machinery and Equipment category covers many items that are common to academic research instruments. Therefore, an index that combined these two would probably be most appropriate for the purpose of making adjustment for inflation in the prices of research equipment.

The various subcategories of the Producer Price Index are weighted according to the proportion they comprise of total purchases of these products to obtain the index of the categories and of the overall Producer Price Index. Therefore, to create a price index composed of categories 116 and 117, a Combined Index was generated which is a weighted average of these two. The weights used to create this Combined Index were the weights used to represent these categories in the overall category of Machinery and Equipment (category 11).

Table F-2 below indicates the values of these price indices from 1980 through 1986, and for the combined index, it shows year-by-year change from 1982-83. The change factors also can be read to indicate inflation rates in percentage terms. For example, the Combined Index increased by a factor of 1.0998 from 1982 to 1985, the change interval encompassed in Phase I of the study. This is the same as saying the index increased by 9.98 percent during this period. Similarly the Combined Index increased by a factor of 1.0815, or by 8.15 percent, over the change interval that applies to Phase II fields: 1983-86.

---

*A third three-digit category, Miscellaneous Instruments (category 118), was also of interest. This category includes Engineering and Scientific Instruments (category 1185). However, according to personnel of the U.S Bureau of Labor Statistics (who compile these indices), separate indices for these categories were first available in March of 1983 Since the base year for the desired comparison could not be obtained, this index could not be used for the current analysis.

Table F-2. Selected Producer Price Indices

Code	Index	1986	1985	1984	1983	1982	1981	1980
116	Specialized industrial equip.	371.3	360.3	348.7	337.1	325.1	307.9	275.8
117	Electrical machinery	257.6	253.8	248.7	240.1	231.6	220.2	201.7
	Combined	285.3	279.8	273.1	263.8	254.4	241.6	219.8
	Change from 1982 (for Phase I)	--	1.0998	1.0735	1.0369			
	Change from 1983 (for Phase II)	1.0815	1.0607	1.0353	--			

NOTE: Combined Index is weighted by ratio of index weights (116 = 1.092, 117 = 3.385)

SOURCE: U.S. Bureau of Labor Statistics

Inflation Adjustment Procedure

Dollar amounts of post-baseline study purchases and expenditures were adjusted for inflation using the change factors for the Combined Producer Price Index shown in Table F-2 above. Thus, for Phase I fields, actual dollar amounts for purchases/expenditures made in 1983 were divided by 1.0369; those in 1984 were divided by 1.0735; and those in 1985 were divided by 1.0998. For post-baseline equipment and other expenditures in Phase II fields, the adjustment factors were 1.0353 (1984), 1.0607 (1985), and 1.0815 (1986). These adjustments were designed to convert post-baseline purchases and expenditures into 1982-83 constant dollars.

For trend comparisons involving the 1985-86 instrument sample, instruments with inflation adjusted prices of less than $10,000 (in 1982-83 constant dollars) were excluded from the analysis.

All inflation-adjusted comparisons also involved an adjustment to the 1985-86 study's institution universe. The first step in this adjustment was to determine the number of institutions that would have been in the universe for the 1985-86 update study if it had been defined using a constant-dollar equivalent of the $3 million R&D expenditures requirement that was used to define the universe for the 1982-83 baseline study. The number of colleges and universities that met the baseline study requirement of $3 million in 1980 R&D expenditures was 157. The number that met the (unadjusted) update study requirement of $3 million in 1984 R&D expenditures was 174 (see Appendix A). In the intervening interval, the combined Producer Price Index increased by a factor of 1.2425. This implies that, in inflation adjusted comparisons between the baseline and update studies, the update study should represent only institutions with 1984 R&D expenditures above $3,000,000 x 1.2425, or $3,727,500. A total of 163 colleges and universities meet this inflation-adjusted requirement. Additional information about numbers of institutions in the three different universes (baseline, update, and update adjusted for inflation) is presented in Appendix H.

As it happens, none of the institutions actually selected in the 1985-86 study sample was among the 11 that would not have been eligible under the inflation-adjusted criterion. Consequently, it was not necessary to discard data from any sampled institutions in order to perform inflation-adjusted comparisons. It was necessary, however, to adjust institution sampling weights to reflect the fact that an inflation-adjusted institution sample for the update study would have been selected from a universe of only 163 institutions rather than from one containing 174 colleges and universities.

Without going into details about the sample design (which is described in a separate methodology report), the 12 smallest colleges/universities in the update study sample were selected with equal selection probability from a stratum consisting of the 103 smallest R&D institutions in the survey universe. Consequently, all had institution selection weights of 103/12=8.583. Using the inflation-adjusted criterion, the number of institutions in the smallest stratum would be reduced (by 11) to 92, and the institution selection weight for the 12 colleges/universities from this stratum would be 92/12=7.667. To produce inflation-adjusted estimates, the adjusted (lower) institution selection weight was used in calculating the final estimation weights for all instrument and department records obtained from the 12 smallest colleges/universities in the update study sample.

In summary, the inflation adjustment procedure involved up to three adjustments to the 1985-86 data:

1. The dollar amounts of purchases/expenditures that occurred after the baseline study were converted (i.e., reduced) to 1982-83 constant dollars.

2. The institution universe was redefined to exclude 11 institutions that did not have in 1984 the constant-dollar equivalent of $3 million in R&D expenditures in 1980. This was done by adjusting (i.e., lowering) the estimation weights associated with all instrument and department records obtained from the 12 smallest R&D institutions in the 1985-86 sample.

3. Comparisons involving the 1985-86 instrument sample excluded instruments with 1982-83 constant-dollar prices under $10,000.

APPENDIX G

SAMPLING ERRORS

SAMPLING ERRORS

The findings presented in this report are estimates based on stratified random samples of university departments and of equipment within departments. Consequently, these estimates are subject to sampling variability. If the questionnaires had been sent to different samples, the responses would not have been identical; some estimates would have been higher, while others would have been lower. In this section, attempts have been made to present estimates of sampling variance for certain selected statistics.

With data collected as part of a complex sampling design, such as the one used in this study, there is often no easy way to produce unbiased estimates of sampling variances. Since the standard statistical packages (e.g., SAS) assume a simple random sampling design, one cannot use these packages to estimate the sampling variability associated with statistics of interest. If the variance of descriptive statistics--such as means and proportions--is estimated using one of these packages, then the resulting variances are usually too small. A class of techniques, called replicated estimates of variance, has been developed to provide a general method of estimating variances for complex sampling designs. The basic idea behind the replication techniques is to use portions (subsamples) of the sample to obtain different estimates of the statistics of interest. The variation of the subsample estimates about the full sample estimate (i.e., the estimate based on the entire sample) is used to measure sampling variances. Different ways of creating these subsamples from the full sample yield different estimates of sampling variance.

The jackknife variance estimation is one of the general approaches to forming subsamples from the full sample for estimating sampling variance. This method can be used in sample designs in which the population is first stratified and then a sample of primary sampling units (PSU's) is selected. The basic design assumed by the jackknife method is one in which the population of PSU's is grouped into L strata, and then two PSU's are selected from each stratum. A replicate is formed by randomly deleting one PSU from a single stratum. This process (i.e., randomly deleting one PSU from a single stratum) is repeated in turn for each stratum. Thus, if there are L strata, then L replicates will be created. Furthermore, estimates of the statistics of interest are obtained from each of these L replicates. The variation of the replicate estimates around their corresponding full sample estimate is used to measure sampling variance of the statistics of interest.

Using the jackknife replication method described above, the sampling variability associated with several statistics of interest was estimated. Tables G1 through G5 present the sampling variance for various statistics selected to represent all combinations of three important parameters: (a) the survey type, whether the instrument survey or the department survey; (b) the type of estimate, whether a total, such a number of systems or aggregate cost, or a ratio, such as a mean or a percentage; and (c) the survey year, whether the 1985-86 (update) survey or 1982-83 (baseline) survey.

Table G-1 exhibits the standard error (SE) of selected statistics for the instrument survey. The estimated standard error of a statistic (a measure of the variation due to sampling) can be used to construct confidence intervals around the full sample estimate. If all possible samples of a given size were surveyed under similar conditions, intervals of 1.965 standard errors below to 1.965 standard errors above a particular estimate would include the average result of these samples in approximately 95 percent of the cases. For example, for the estimated total purchase price of all in-use academic research instrument systems in 1985, the 95 percent confidence interval is $1,982 million ± 1.965 times a standard error of $42 million. If the above procedure were followed for every possible sample, about 95 percent of the intervals would include the average number from all possible samples.

In order to compare the precision of estimates for a particular estimate in 1985-86 and 1982-83, both the standard error and the magnitude of the estimate have to be taken into consideration. For example, the standard error for the total NSF funding of in-use research equipment in 1985-86 is estimated to be $25 million, while the corresponding estimate for 1982-83 is $22 million. It would not be correct to conclude that the 1982-83 estimate is more precise than the one for 1985-86, since the amount of NSF funding of in-use research equipment in 1985-86 is considerably greater than the corresponding figure in 1982-83. To facilitate the comparisons of the precision of estimates across the two survey years (i.e., 1985-86 and 1982-83), coefficients of variation (CV's) of selected estimates have been presented in Table G-2. Table G-2 indicates that, in general, the estimates for 1985-86 have smaller CV's than the corresponding estimates in 1982-83. This improvement in precision is an expected consequence of improvements in the study's sampling design from 1982-83 to 1985-86.

Tables G-3 and G-4 present standard errors and CV's selected estimates for the department survey in 1985-86 and 1982-83. Table G-4 also shows that in general the estimates for 1985-86 have smaller CV's than the corresponding estimates in 1982-83. Table G-5 presents the standard errors and CV's for selected trend statistics (i.e., percent change in number of in-use research systems and in aggregate purchase price of in-use research systems). C mparing these CV's to the ones shown in Table G-2, it may be seen that estimates of <u>change</u> from 1982-83 to 1985-86 in a given statistic are generally more precise than the estimates of the statistic itself in either 1982-83 or 1985-86.

Table G-1. Standard error (SE) of selected estimates: Equipment survey

	Total		Engineering		Physical sciences		Computer science		Biological sciences	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Estimates of Totals										
Number of in-use systems										
1985-86	53,000	-	9,300	1,088	12,300	822	2,200	303	22,300	1,228
1982-83	36,300	-	6,800	918	8,800	613	900	167	15,300	880
Aggregate purchase price (dollars in millions)										
1985-86	$1,982	$42	$372	$39	$543	$36	$100	$13	$643	$31
1982-83	$1,311	$32	$261	$32	$390	$31	$50	$9	$420	$25
NSF funding of in-use equipment (dollars in millions)										
1985-86	$306	$25	$38	$11	$139	$11	$26	$5	$51	$6
1982-83	$233	$22	$35	$7	$118	$13	$11	$2	$35	$4
Estimated Ratios										
Mean purchase price per system (dollars in thousands)										
1985-86	$36.8	$0.8	$40.1	$1.7	$44.1	$1.3	$46.0	$2.7	$28.9	$0.8
1982-83	$36.1	$0.9	$38.4	$2.[illegible]	$44.6	$1.8	$57.8	$5.7	$27.4	$0.7
Percent of in-use systems that were acquired with no Federal funding										
1985-86	45%	2%	54%	6%	32%	2%	41%	7%	44%	2%
1982-83	40%	3%	47%	7%	26%	2%	45%	10%	41%	3%
Percent of in-use systems that are less than 6 years of age										
1985-86	63%	1%	71%	3%	62%	1%	97%	1%	57%	2%
1982-83	62%	2%	67%	3%	59%	3%	94%	3%	58%	3%
Mean number of users per system										
1985-86	14.2	0.5	14.0	1.6	14.7	0.9	46.4	5.1	11.6	0.3
1982-83	13.9	0.7	13.0	0.9	15.4	1.2	48.6	15.5	11.4	0.3

1 [illegible]

Table G-2. Coefficient of variation (CV) of selected estimates: Equipment survey

	Total	Engineering	Physical sciences	Computer science	Biological sciences
Estimates of Totals					
Number of in-use systems					
1985-86	-	12%	7%	14%	6%
1982-83	-	14%	7%	19%	6%
Aggregate purchase price					
1985-86	2%	11%	7%	13%	5%
1982-83	2%	12%	8%	17%	6%
NSF funding of in-use equipment					
1985-86	8%	28%	8%	21%	13%
1982-83	9%	19%	10%	22%	12%
Estimated Ratios					
Mean purchase price per system					
1985-86	2%	4%	3%	6%	3%
1982-83	2%	6%	4%	10%	3%
Percent of in-use systems that were acquired with no Federal funding					
1985-86	5%	11%	7%	16%	5%
1982-83	7%	15%	9%	23%	7%
Percent of in-use systems systems that are less than 6 years of age					
1985-86	1%	4%	2%	1%	3%
1982-83	3%	5%	4%	3%	5%
Mean number of users per system					
1985-86	4%	11%	6%	13%	2%
1982-83	5%	7%	8%	32%	3%

Table G-3. Standard error (SE) of selected estimates: Department survey

	Total		Engineering		Physical sciences		Computer science		Biological sciences	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Estimates of Totals										
Annual expenditures for research equipment (dollars in millions)										
1985-86	$687	$45	$164	$12	$167	$20	$47	$7	$190	$15
1982-83	$413	$23	$86	$13	$96	$9	$20	$5	$132	$13
Estimated Ratios										
Percent of departments reporting insufficient equipment										
1985-86	35%	2%	50%	6%	32%	8%	44%	6%	28%	3%
1982-83	36%	2%	50%	3%	40%	5%	45%	15%	26%	4%
Percent of departments needing equipment in $50,000-$1 million range										
1985-86	35%	2%	29%	3%	53%	4%	24%	6%	35%	4%
1982-83	26%	2%	28%	4%	43%	4%	26%	7%	20%	4%

Table G-4. Coefficient of variation (CV) of selected estimates: Department survey

	Total	Engineering	Physical sciences	Computer science	Biological sciences
Estimates of Totals					
Annual expenditures for research equipment					
1985-86	7%	8%	12%	15%	8%
1982-83	6%	15%	10%	25%	10%
Estimated Ratios					
Percent of departments reporting insufficient equipment					
1985-86	6%	11%	25%	14%	10%
1982-83	6%	7%	12%	34%	14%
Percent of departments needing equipment in $50,000-$1 million range					
1985-86	5%	10%	8%	24%	10%
1982-83	7%	16%	8%	25%	20%

Table G-5. Standard error (SE) and coefficient of variation (CV) of selected trend statistics: Equipment file

	Total	Engineering	Physical sciences	Computer science	Biological sciences
Number of in-use research systems:					
1985-86	53,900	9,300	12,300	2,200	22,300
1985-86, inflation-adjusted	51,900	[illegible],800	12,000	2,100	21,800
1982-83	36,300	6,800	8,800	900	15,300
Percent change	43%	30%	33%	138%	42%
SE	-	3%	2%	21%	2%
CV	-	11%	5%	15%	4%
Aggregate purchase price of in-use research systems:					
1985-86	$1,981.6	$371.8	$543.0	$100.2	$643.4
1985-86, inflation-adjusted	$1,882.5	$349.[illegible]	$511.4	$93.1	$623.5
1982-83	$1,310.7	$261.3	$390.[illegible]	$50.4	$420.3
Percent change	44%	34%	31%	85%	48%
SE	1%	3%	2%	10%	[illegible]%
CV	1[illegible]	9%	6%	12%	3%

APPENDIX H

TRENDS IN NUMBERS OF INSTITUTIONS

Table H-1. Trends in the number of institutions with $3,000,000 or more in S/E R&D expenditures by field and institution type: National estimates, 1982-83 to 1985-86

Field and institution type	Number of institutions			
	1982-83	1985-86		Percent change[2]
		Unadjusted	Adjusted[2]	
Total	247	266	255	3%
FIELD				
Engineering	155	174	163	5
Chemical	155	174	163	[illegible]
Civil	155	174	163	5
Electrical	155	174	163	5
Mechanical	155	174	163	5
Metallurgical/materials	155	174	163	5
Other, n.e.c	155	174	163	5
Agricultural sciences	155	174	163	5
Agronomic sciences	155	174	163	5
Animal sciences	155	174	163	5
Natural resources management	155	174	163	5
Biological sciences	247	266	255	3
In medical schools	92	92	92	0
In colleges/universities	155	174	163	5
Computer science	155	174	163	5
Environmental sciences	155	174	163	5
Materials science	155	174	163	5
Physical sciences	155	174	163	5
Chemistry	155	174	163	5
Physics/astronomy	155	174	163	5
Interdisciplinary, n.e.c	155	174	163	5
INSTITUTION TYPE				
Colleges/universities	155	174	163	5
Private	51	56	51	0
Public	104	118	112	8
Top 20 in R&D	20	20	20	0
Not in top 20	135	154	143	6
Medical schools	92	92	92	0

[1] In this analysis, the 92 medical schools with $3,000,000 or more R&D expenditures are counted as separate "institutions," whether or not they are affiliated with larger universities.

[2] Estimates are adjusted for inflation. For procedure, see Appendix F.

[3] Includes the top 20 medical schools and the top 20 colleges/universities, exclusive of their medical schools.

SOURCE: National Science Foundation, SRS