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ABSTRACT

For several decades there has been a general concern that the level of research funding for academic instrumentation was not sufficient to keep pace with the requirements of cutting edge research. To develop the factual trend data necessary to understand the depth of the problems in academia and thus provide an adequate response to these concerns, Congress directed the National Science Foundation to collect data that would aid in an accurate assessment of the aforementioned concern. The National Survey of Academic Research Instruments and Instrumentation Needs (Instrument Survey) was developed to collect data concerning scientific research instruments and the academic departments and facilities in which they are located in the fields of agricultural, biological, computer, environmental, and physical science and engineering. A panel of 55 colleges and universities and 24 medical schools which account for 90 percent of expenditures for academic research and development in science and engineering were surveyed. This document covers data gathered for 1992. (ZWH)

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ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS:

1992

ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS: 1992

Carolyn B. Arena,
Project Officer

September 1994
NSF 94-321

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An expert advisory panel contributed to the review of this report and gave overall direction for the survey redesign for the next report. The members of this panel were

James Adams, Chairman, Department of Natural Science, University of Maryland, Eastern Shore

Dennis Barnes, President, Southeastern Universities Research Association, Washington, DC

Vaughn Blankenship, Professor of Political Science, Institute of Government and Public Affairs, University of Illinois, Chicago

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EXECUTIVE SUMMARY

BACKGROUND

The National Survey of Academic Research Instruments and Instrumentation Needs (Instrumentation Survey) collects data concerning scientific research instruments and the academic units (departments and facilities)[1] in which they are located in the fields of agricultural, biological, computer, environmental, and physical science and engineering.

The roots of the Instrumentation Survey trace back to the late 1970s, when there was general concern that the level of research funding for academic instrumentation was not sufficient to keep pace with the requirements of cutting-edge research, a condition that was seriously weakening the quality of the Nation's academic research capabilities.

To develop the factual trend data necessary to understand the depth of the problem in academia and thus to provide an adequate response to these concerns, Congress directed the National Science Foundation (NSF) 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 needs for scientific and technological instrumentation" (Public Law 96-44, Section 7).

The Instrumentation Survey was developed by NSF to fulfill this congressional mandate. It is sponsored jointly by NSF and the National Institutes of Health (NIH). The survey draws its information from a panel of 55 colleges and universities and 24 medical schools, which represent the 318 institutions that together account for more than 90 percent of expenditures for academic research and development (R&D) in science and engineering (S&E) fields in the United States. This is the fourth cycle of the survey and covers data for 1992; previous cycles were conducted in 1983–84, 1986–87, and 1989–90.

EXPENDITURES FOR THE PURCHASE AND UPKEEP OF ACADEMIC SCIENTIFIC RESEARCH INSTRUMENTATION

Total Expenditures

The total annual expenditures for the purchase of academic scientific research instrumentation were $1,367 million in 1992, an increase in current dollars of approximately 21 percent from the $1,134 million in 1988–89. This continues the trend of increasing expenditures for the purchase of scientific research instrumentation since the survey began in 1982–83.

The rate of increase has slowed in recent years, however: The increase between 1988–89 and 19[illegible], was 5 percent in constant dollars, contrasted with a 51-percent constant-dollar increase between 1982–83 and 1985–86.

Sources of Funds

Federal Sources

In 1992, the Federal Government provided $650 million of the $1,367 million total expenditures for academic research instrumentation. The 48-percent share provided by the Federal Government has declined slightly from the 51-percent share in 1982–83.

NSF was the largest single Federal source in fiscal year (FY) 1992, providing $191 million, or 14 percent of total expenditures. NIH was the second largest Federal source, contributing $185 million, also 14 percent of the total expenditures. The Department of Energy contributed $98 million, or 7 percent of the total.

[1] A department is an institutional unit that awards academic degrees and has faculty assigned to it. A facility is an institutional unit that does not award academic degrees and does not have faculty assigned to it. Unit is a generic term that includes both departments and facilities.

Non-Federal Sources

Non-Federal sources provided the remainder (52 percent) of the funds for academic research instrumentation, with the largest single source of funds being the academic institutions themselves. In 1992, colleges and universities contributed $329 million, or 24 percent, of the $1,367 million spent to purchase research instruments.

State governments comprised the second largest non-Federal source of funds to purchase research instruments. In FY 1992, they contributed $170 million, or 12 percent of the total. Industry contributed $103 million, or 8 percent, of the total expenditures.

Maintenance/Repair of Existing Stock

Total expenditures for maintenance/repair of the current stock of academic research instruments were $304 million in 1992, an increase of 6 percent from the 1988–89 total of $287 million. This continues the trend of increases in total expenditures for maintenance/repair that began in 1982–83. However, the rate of increase has slowed and, in constant dollars, expenditures for maintenance/repair decreased by 8 percent between 1988–89 and 1992.

Operation of Existing Stock

Total expenditures for the operation of scientific research instrumentation in 1992 were $530 million, a decrease of 27 percent from 1988–89, the first time these data were collected in the survey. Expenditures included in this category include $435 million for the costs of salaries for technicians operating the instruments, and $95 million in outlays for supplies for operation.

Instrumentation Purchases as a Proportion of Total Research & Development Expenditures

Research instrumentation purchases as a percentage of total R&D expenditures in science and engineering fields remained relatively stable. In particular, since 1985–86, this proportion has remained almost constant at 12 to 13 percent.

Adequacy of Current Instrumentation

Status and Capability to Meet the Needs of Current Faculty

In an attempt to assess the current stock of instrumentation available to researchers, department chairs and heads of facilities were asked several questions concerning the ability of their instrumentation to fulfill the needs of their current faculty, the quality of the support services available to them, and the extent of their most pressing needs for instrumentation.

Seventy-nine percent of respondents reported that their instrument needs had increased over the past 3 years, and 68 percent reported that the amount of usable equipment had increased. At the same time, 48 percent responded that the adequacy of that equipment had improved over the last 3 years. (An additional 34 percent reported that the adequacy of their equipment had remained the same.) Thus, although their needs have increased during the past 3 years, respondents reported overall a general ability to keep pace with fulfilling the needs of their researchers for access to equipment.

However, when asked to rank their existing equipment in terms of its overall capability to allow the research faculty to pursue their major research interests, 31 percent of the respondents reported that the capability was insufficient. An additional 53 percent reported the capability as adequate, and only 16 percent reported the capability as excellent.

Responding to a related question, more than half of all respondents (56 percent) reported that there are subject matters in which current investigators in their department or facility cannot perform critical experiments because needed equipment is lacking.

In an encouraging trend, however, this proportion has been decreasing since the Instrumentation Survey began in 1982–83. In that year, 74 percent of the respondents noted that the lack of instrumentation limited their current investigators from performing critical experiments. In the 1989–90 survey, this figure was 61 percent, and the proportion dropped still further in 1992. However, certain fields of science still report major problems in this area. In the physical sciences, for example, 72 percent of the respondents reported that critical experiments cannot be performed in certain areas, and 70 percent of the respondents in the agricultural sciences reported this condition.

Amount of Usable Instrumentation

A majority of respondents (53 percent) reported that the amount of usable research equipment on hand at their departments and facilities increased between 1989–90 and 1992; an additional 15 percent reported that it had increased substantially (by 50 percent or more). Only 7 percent reported that the amount had decreased. For each S&E field, a majority of respondents reported that the amount of usable research equipment had increased.

Priority Needs for Instrumentation

Department chairs and heads of facilities were asked to identify the three pieces of research instrumentation with a purchase price of $20,000 or more that were the "topmost priorities" in their units. They were asked to list these items in priority order, estimate the purchase price of each top priority instrument, and state the reason it was needed. If just these three top priority items were to be purchased, the total estimated purchase price would be $2,730 million. Of this total, an estimated $1,202 million, or 44 percent, is the cost of purchasing only the first priority research instruments.

SURVEY BACKGROUND AND METHODOLOGY

The National Survey of Academic Research Instruments and Instrumentation Needs (Instrumentation Survey) collects data concerning scientific research instruments and the academic units (departments and facilities)[1] in which they are located in the fields of agricultural, biological, computer, environmental, and physical science and engineering.

BACKGROUND

The roots of the Instrumentation Survey trace back to the late 1970s, when there was concern that the level of funding for academic instrumentation was not sufficient to keep pace with the requirements of cutting-edge research, a condition that was seriously weakening the quality of the Nation's academic research capabilities.

To develop the factual information necessary to understand the depth of the problem in academia and thus to provide an adequate response to these concerns, Congress directed NSF (the focal agency in the Federal Government to collect, maintain, and disseminate information on the resources devoted to science and technology in the United States) 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 needs for scientific and technological instrumentation" (Public Law 96-44, section 7).

To fulfill this congressional mandate, NSF developed and has conducted to date four cycles of the Instrumentation Survey. The survey is funded jointly by the NSF and the NIH. It focuses on four main aspects of academic scientific research instrumentation:

- Expenditures made by departments and facilities for the purchase of research instruments and the sources of funds for those purchases;
- Maintenance, repair, and operating costs connected with the stock of research instruments;
- Status, adequacy, and capability of current research instruments; and
- Needs for upgraded or additional instrumentation.

GENERAL METHODOLOGY

The first cycle was a baseline survey conducted in 1983–84. It had a panel of 67 institutions: 43 colleges and universities and 24 medical colleges. In Cycle II, conducted in 1986–87, the sample of colleges and universities was expanded to 55, for a total of 79 institutions. Cycle III, in 1989–90, used the same panel of 79. This panel was again retained in Cycle IV.

Each cycle of the survey has collected two types of data from two different sets of respondents:

- The heads of academic departments and research facilities complete a *Department Facility Questionnaire* in which they provide data for their entire units regarding expenditures for purchasing research instruments, the sources of these funds, their provisions for maintaining and repairing the instruments, and an evaluation of all their research instruments in terms of adequacy, capabilities, and needs; and
- Principal investigators complete an *Instrument Data Sheet* in which they provide detailed data about individual pieces of research equipment (e.g., its adequacy for research, pattern of usage, and technical capabilities).

[1] A department is an institutional unit that awards academic degrees and has faculty assigned to it. A facility is an institutional unit that does not award academic degrees and does not have faculty assigned to it. Unit is a generic term that includes both departments and facilities.

The findings from the Instrumentation Survey are presented as national estimates, calculated using department and facility data statistically weighted to represent all research departments and facilities in the agricultural, biological, environmental, physical, and computer sciences and in engineering. The final weights for these estimates are the product of the institution sampling weight (for each stratum) and the nonresponse adjustment factors for the institution and the department or facility. These results may be generalized to the universe of 318 institutions from which the panel of 79 institutions was drawn.

In addition, the findings are compared with those from the previous three cycles. Data on the estimated expenditures for the purchase, maintenance/repair, and operation of scientific research instrumentation are presented in current dollars, and in constant dollars where indicated. When presented, constant dollar figures have been calculated using the gross domestic product (GDP) price deflator and a base year of 1987.[2]

[2] The GDP deflator was selected as the best overall price deflator available at this time for the scientific instrumentation encompassed in this survey. We recognize that price deflators based upon the GDP, the consumer price index (CPI), and other macro indices do not provide the level of detail that might be desired to measure accurately the price changes in the specific scientific research instruments included in this survey. In addition, they do not assess the effects of the major qualitative improvements that have marked the development of some scientific instruments, particularly computers, which have experienced a concomitant dramatic decrease in price.

There are more detailed deflators for certain classes of instruments such as the miscellaneous instruments (MI) subcategory (118) of the producer price index (PPI), the engineering and scientific instruments (ESI) subcategory (1185) of the engineering and scientific instruments index, and the producers durable equipment (PDE) deflators for computers and peripheral equipment. However, these deflators also have limitations on their use for the Instrumentation Survey. First, they do not include the entire domain of scientific instrumentation. Second, they include extraneous items that are not included in the Instrumentation Survey. For example, the MI includes drafting instruments and furniture. The remaining indicators are also limited either by the time periods or by the instruments to which they apply: The ESI does not extend back to 1982, the PDE encompasses only computers and associated pieces of equipment. For more information regarding price deflators, see *National Survey of Academic Research Instruments and Instrumentation Needs, Methodology Report: 1992*. To obtain a copy, contact Carolyn Arena, National Science Foundation, (703) 306-1774.

Methodology for 1992 Survey

Cycle IV of the Instrumentation Survey consists of two phases. In Phase 1, data for FY 1992 were collected from 1,414 S&E departments and facilities having at least one research instrument with a minimum purchase price of $20,000. These academic units are located at a panel of 79 colleges, universities, and medical schools selected from a universe of 318 institutions. The institutions are divided into two samples:

- The first sample—55 colleges and universities—represents the universe of 214 institutions that had R&D expenditures of more than $3 million in FY 1991. The probability of selection for elements in this sample was proportionate approximately to the total expenditures for R&D in those S&E fields included in the Instrumentation Survey in FY 1991.

- The second sample—24 medical schools—represents the universe of 104 medical schools that received at least $3 million in extramural awards for research from NIH in FY 1991. The probability of selection for elements in this second sample was proportionate approximately to the total amount of dollars for extramural awards given to medical institutions by NIH in FY 1991. The elements in these samples are listed in appendix C.

The response rate for the 79 institutions in the panel was 97 percent. The department/facility response rate was 84 percent. The response rate for the questionnaire items ranged from 95 to 100 percent.

Changes in Data Collection Procedures for Cycle IV

The data collection procedures used in Cycle IV, Phase 1, differ from those used in earlier cycles of the Instrumentation Survey in three ways.

1. *Minimum cost of research instruments.* To be eligible for inclusion in the three previous cycles, a department or facility must have had

at least one research instrument with a purchase price of $10,000 or more. Similarly, only those research instruments with a purchase price of $10,000 or more were eligible for inclusion in the instrument sample in the survey. In Cycle IV, the $10,000 minimum purchase price criterion was increased to $20,000. In this report, trend data for the previous cycles of the survey have been adjusted to reflect this change. (A detailed analysis of the effects of this change on data in the survey is available in a separate methodology report.[3])

2. *Dual questionnaires.* In Cycles I through III, the two questionnaires connected with the survey were administered concurrently. (The *Instrument Data Sheet* collected data regarding the use, condition, and status of individual pieces of research equipment and the *Department/Facility Questionnaire* collected data regarding equipment expenditures and needs for the total unit.) This practice was changed in Cycle IV to reduce respondent burden. Only the Department/Facility Questionnaire was used to gather 1992 data, and information on individual pieces of research equipment was not collected. Therefore, this report, unlike those for previous cycles, does not include detailed information regarding the stock of research instruments.

   Instrumentation data and department/facility data again will be collected concurrently in Cycle IV, Phase 2. This phase will be conducted during 1994 and detailed information regarding the status of the stock of instruments will be available in the next series of reports.

3. *Change in survey collection periods.* During Cycles I, II, and III, data were collected during a 2-year period. In all surveys, information about current equipment needs and priorities was obtained with reference to the actual survey year (i.e., 1983, 1986, and 1989 for the physical and computer sciences and engineering—Phase I; 1984, 1987, and 1990 for the agricultural, biological, and environmental sciences—Phase II). Information about equipment dollar amounts and expenditures refers to the year preceding the survey (i.e., 1982, 1985, and 1988 for Phase I fields; 1983, 1986, and 1989 for the Phase II fields).

Therefore, the data presented in this report for Cycles I, II, and III are displayed in 2-year increments (e.g., 1988–89). In Cycle IV, data for all fields of science were collected in the same year, so that the resulting reporting period covers only 1992.

Data Limitations

The presentation of data in this report is also affected by a major data collection change made in Cycle III, 1988–89. For the first time data were collected for instruments with a purchase price of $1 million or more. Many of these instruments were in effect separate academic units having an integrated complex of interrelated equipment that could not meaningfully be disaggregated, such as research vessels, telescopes, wind tunnels, and central computer centers. A total of 121 of these integrated facilities/instruments was added in Cycle III. Labeled "supersystems" in Cycle III, all were located in facilities.

The addition of these large systems beginning only in Cycle III presents a dilemma for the analysis of trends in this report. Simply adding the data for these large, integrated systems to the existing totals would distort the analysis of trends across cycles of the survey. Since these instruments were all located in facilities, the analysis tables in this report have been subdivided to show three separate totals:

- *Departments.* The data for departments are comparable for all four cycles of the Instrumentation Survey, 1982–92. Data for all four cycles are presented in this report and trends can be analyzed.

[3] *National Survey of Academic Research Instruments and Instrumentation Needs, Methodology Report: 1992,* ibid.

- *Facilities.* The data for facilities are not comparable for the entire series of the Instrumentation Survey. The data for 1982–83 (Cycle I) and 1985–86 (Cycle II) are comparable because they *do not* contain data for these large, integrated systems; the data for 1988–89 (Cycle III) and 1992 (Cycle IV, Phase 1) are comparable because they *do* contain data for these systems. Therefore, in this report, any trend comparisons for facilities will be made only between the 1988–89 and 1992 survey data.

- *All units.* The term "unit" refers to an academic entity that may be either a department or a facility. Thus "total all units" data in the tables represent information for all departments plus all facilities. A more detailed discussion of the methodological changes that were made in Cycle IV is presented in *National Survey of Academic Research Instruments and Instrumentation Needs, Methodology Report: 1992.*

Sampling Errors

The estimates presented in this report are based on samples and are subject to variability due to sampling error. Most overall estimates (not broken down by field) have sampling errors (coefficients of variation) that range from 4 to 8 percent. This implies a 95-percent confidence interval of twice that magnitude, i.e., plus or minus 8 to 16 percent of the reported estimate. Estimates for the detail data (i.e., estimates by field of science) have sampling errors two to three times larger than those for all fields combined.

EXPENDITURES FOR THE PURCHASE OF ACADEMIC SCIENTIFIC RESEARCH INSTRUMENTATION

TOTAL EXPENDITURES

The total annual expenditures for the purchase of academic scientific research instrumentation were $1,367 million in 1992, an increase in current dollars of 21 percent from the $1,134 million spent in 1988–89 (table 1). This continues the trend of increasing expenditures for the purchase of scientific research instrumentation evident since the survey began in 1982–83. However, the rate of increase has slowed considerably, as evidenced by the contrast from the 66 percent increase between 1982–83 and 1985–86. In constant dollars, the increase between 1988–89 and 1992 was 5 percent compared with a 51-percent increase between 1982–83 and 1985–86.

Between the 1988–89 and 1992 surveys, some fields of science experienced large increases in their expenditures for research instruments. In particular, expenditures for the purchase of equipment in environmental sciences more than doubled between the two survey periods, from $63 million to $131 million (table 1). Similarly, the expenditures in the biological sciences increased by 53 percent from $253 million in 1988–89 to $387 million in 1992. Engineering and physical sciences also increased their expenditures during this time period, by 25 and 30 percent, respectively.

Decreases in expenditures were experienced in agriculture, computer science, and the multidisciplinary fields (table 1). The greatest decline in expenditures for the purchase of research instrumentation occurred in computer science. In 1988–89, $228 million was spent on research instrumentation; in 1992, expenditures declined 35 percent to $148 million. This overall decrease in expenditures for the purchase of instrumentation in computer science was due entirely to a sharp decline in expenditures within computer science facilities; there were increased expenditures by the computer science departments during this period (from $34 million to $54 million). Annual expenditures at computer science facilities decreased 51 percent from $193 million in 1988–89 to $94 million in 1992.

The decline in expenditures for the purchase of equipment at computer science facilities between the 1988–89 and 1992 surveys may be attributed to several factors. First, the estimate of the total number of in-scope facilities changed between surveys. In the 1988–89 survey, the national estimate of the number of computer science facilities in which research was conducted was 226. (This figure includes centralized mainframe computer centers.) In 1992, the estimated number was 204, a decline of almost 10 percent.

The primary reason for this decline in the national estimate of the number of computer science facilities was that the reported activities at many of these facilities had changed. During 1988–89, respondents for many of the computer science centers in the survey sample reported that research was being performed at those facilities; in 1992 the respondents reported that research was not being performed there. Therefore, although those centers were in-scope for the 1988–89 survey, they were out of scope of the 1992 survey and were therefore ineligible for the 1992 sample. (The computer science centers in question accounted for approximately $39 million of the $193 million expenditures at computer science facilities in the 1988–89 survey.) Additional details of this analysis of computer science facilities in the two surveys are presented in appendix A.

A second major factor in the reported decline in expenditures at computer science facilities between the survey years of 1988–89 and 1992 was that the computational power of computers continued to increase while their prices declined. On many campuses, this has allowed administrators to move computer support for research away from an emphasis on large mainframe computers housed in central locations. Instead, the emphasis is increasingly moving toward the purchase of many smaller yet very powerful computers that are now located in the laboratories and offices of the researchers themselves.

Therefore, the overall expenditures for computer research instruments may not have declined; they may simply have moved from being reported as expenditures for the discipline of computer science (if

Table 1. Annual expenditures for the purchase of academic research instruments, by type of unit and field of science and engineering: 1982-83 to 1992

[Dollars in millions]

Type of unit and field of science and engineering	1982-83	1985-86	1988-89	1992
Total, all units	401	664	1,134	1,367
Engineering	91	171	267	335
Physical sciences	90	160	225	292
Environmental sciences	33	51	63	131
Computer science	20	47	228	148
Agricultural sciences	26	30	44	40
Biological sciences	131	183	253	387
Other, multidisciplinary fields	12	22	54	33
Total, departments	341	559	715	1,031
Engineering	80	153	234	277
Physical sciences	84	140	160	246
Environmental sciences	20	39	33	67
Computer science	18	39	34	54
Agricultural sciences	15	26	34	36
Biological sciences	124	162	211	350
Other, multidisciplinary fields	0	0	9	1
Total, facilities	60	105	419	335
Engineering	11	18	32	58
Physical sciences	6	20	66	46
Environmental sciences	13	12	30	64
Computer science	2	8	193	94
Agricultural sciences	11	4	10	5
Biological sciences	6	20	43	37
Other, multidisciplinary fields	12	22	45	32

NOTE: Years 1982-83 and 1985-86 do not contain supersystems (units having an integrated instrument system with a purchase price of generally $1,000,000 or more).

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

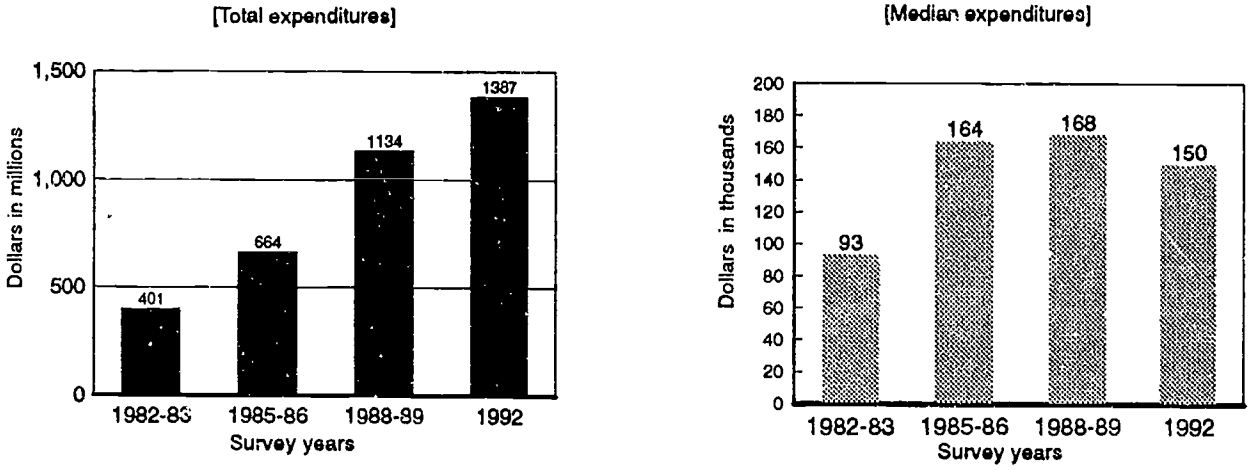
they were previously housed in large, centralized computer science facilities) to being reported as expenditures by the research disciplines that use the computers.

Median Expenditures

In addition to comparing trend changes in total expenditures for academic research instrumentation, another way of analyzing the amount of resources available to individual departments or facilities is through the analysis of median expenditures per unit. The institutions in this survey are large, dynamic, generally growing entities; because there are more students and a higher level of activity between each cycle of the Instrumentation Survey, the total number of departments and facilities at these institutions tends to increase. Therefore, part of the increase in total expenditures in each survey cycle is a result of the larger number of units in these institutions; i.e., as the number of units increases, the total expenditures at the institution also tend to increase. Using the measure of median expenditures per unit allows an analysis of change in the pattern of expenditures that is independent of the increase in the number of units (figure 1).

The median expenditure for the purchase of equipment for all units and all fields of science declined from $168,000 in 1988–89 to $150,000 in

Figure 1. Total expenditures and median expenditures per unit for the purchase of academic research equipment: 1982-92



SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Two fields of science had increases in median expenditures for the purchase of scientific research instrumentation. Median expenditures for environmental sciences increased by 29 percent, from $101,000 in 1988–89 to $130,000 in 1992 (table 2). This increase is consistent with the increase of 108 percent in total annual expenditures for the purchase of equipment for environmental sciences during that same period, from $63 million in 1988–89 to $131 million in 1992. Median expenditures for the purchase of instrumentation for the physical sciences also increased, from $347,000 in 1988–89 to $437,000 in 1992, an increase of 26 percent.

Respondents from four fields of science reported decreases in median expenditures for the purchase of scientific research instrumentation between 1988–89 and 1992. Agricultural sciences declined by 28 percent, biological sciences declined by 13 percent, and engineering declined by 11 percent (table B-1). But the decline was greatest for the computer sciences: 49 percent between 1988-89 and 1992, from $490,000 to $250,000. This decrease was confined to computer science facilities. As already noted, changes in data for computer science facilities are due to several factors, which are more fully presented in appendix A.

SOURCES OF FUNDS

Federal Sources

In 1992 the Federal Government provided $650 million of the $1,367 million total expenditures for academic research instrumentation (table 2). The resulting 48 percent share provided by the Federal Government has declined slightly from the 51 percent share in 1982–83 (table B-2).

The relative importance of Federal funds for the purchase of research instrumentation varies considerably by field of science and engineering. For example, the Federal Government has been the major source of funds for the physical sciences throughout the period covered by the Instrumentation Survey. The level of this support has been consistent over time, ranging from 66 percent in 1982–83 to 68 percent in 1992.

Similarly, the Federal Government provided about half of the support for instrumentation purchases in the biological sciences during this period, with the proportion ranging from 48 to 54 percent of the total purchases since 1982–83.

Table 2. Expenditures for the purchase of academic research instruments, by source of funds: 1992

[Dollars in millions]

Source of funds	Total
Total	1,367
Federal, total	650
National Science Foundation	191
National Institutes of Health	185
Department of Defense	87
Department of Energy	98
Department of Agriculture	13
Other	76
Non-Federal, total	717
Institution funds	329
State and local governments	170
Private, nonprofit organizations	93
Industry	103
Other	23

NOTE: Because of rounding, details may not add to totals.

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

The Federal contribution for the agricultural sciences was consistently the smallest proportion of the fields covered by the survey, ranging from 24 to 27 percent of total purchases.

The proportion of Federal funding for instrumentation in the environmental sciences has increased substantially since 1982–83, reflecting in part the national aspect of environmental problems. In the first cycle of the Instrumentation Survey, the Federal Government provided 43 percent of the funds for the purchase of scientific instrumentation. This increased slightly to 47 percent in 1985–86, and reached a 61 percent Federal share in 1992. (This question was not asked on the 1988–89 survey.)

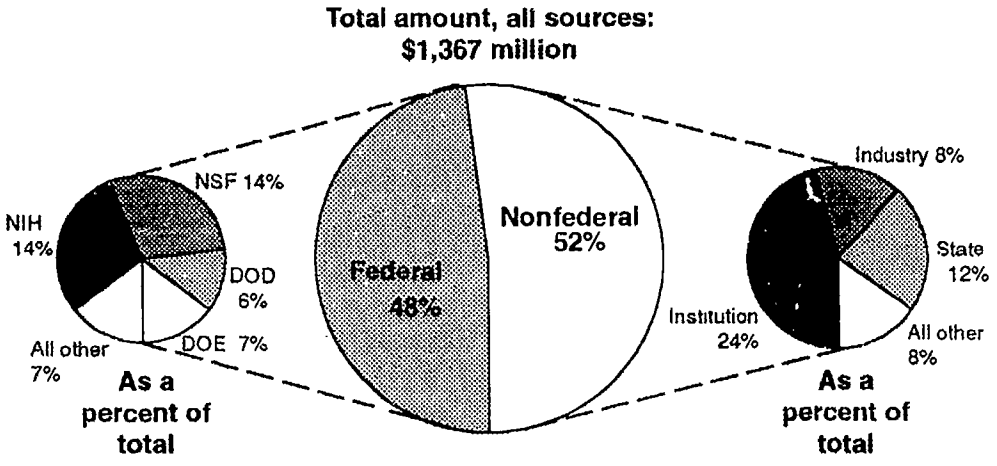
The total purchases of computer science research instrumentation grew dramatically since 1982–83 increasing more than sevenfold from $20 million in 1982–83 to $148 million in 1992 (table 1). The Federal Government's total expenditures increased but did not keep pace proportionately. The Federal share was 49 percent of the $20 million total expenditures in 1982–83 and 16 percent of the $148 million in 1992.

Among the Federal agencies providing funding for the purchase of scientific research instrumentation, NSF was the largest single source in FY 1992. It provided $191 million, or 14 percent of total expenditures. NIH was the second largest source, contributing $185 million, also 14 percent of the total expenditures. The Department of Energy contributed $98 million or 7 percent of the total (tables 2 and B-3, figure 2).

Non-Federal Sources

Non-Federal sources provided the majority (52 percent) of funding support for the purchase of academic research instrumentation in 1992 (table B-3). Indeed, the largest single source of funds for the purchase of research instrumentation was the

Figure 2. Sources of funds for the purchase of academic research instrumentation: 1992



SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

institutions themselves. The institutions contributed $329 million, or 24 percent of the $1,367 million that was spent in 1992 to purchase research instrumentation.[5]

The second largest source of non-Federal funds for the purchase of academic research instrumentation was grants and appropriations from State and/or local governments. In FY 1992, State/local governments contributed $170 million or 12 percent of the total expenditures for academic research instrumentation. Industry contributed $103 million or 8 percent of the total in 1992.

Total Annual Expenditures for the Purchase of Instrumentation as a Percentage of Total R&D Expenditures

Although the total expenditures for the purchase of scientific research instrumentation have increased considerably since the Instrumentation Survey began in 1982–83, the proportion of instrumentation purchases as a percentage of total R&D expenditures in S&E fields remained relatively stable. In particular, since 1985–86 this proportion has remained almost constant at 12 to 13 percent (table B-4).

There is considerable variation in this proportion among the S&E fields, however. For example, expenditures for the purchase of research instrumentation as a percentage of total R&D expenditures is nine times greater for computer science

[5] Institutional funds generally come from one of four sources: indirect cost recovery from awards from the Federal Government and other sources; State operating appropriations from general revenues; student tuition; and unrestricted gifts and income (e.g., endowments).

than for agricultural sciences, reflecting in part the short shelf life of state-of-the-art computer systems and the resulting need for frequent upgrading to maintain research capability.

The large recent increases in total expenditures for research instrumentation for environmental sciences also are reflected in this percentage. As noted earlier, total expenditures for the purchase of research instrumentation for environmental sciences increased by 108 percent between 1988–89 and 1992; at the same time, expenditures for the purchase of instrumentation as a percentage of total R&D expenditures increased from 7 percent in 1988–89 to 12 percent in 1992.

Expenditures for Maintenance/Repair and Operation of Academic Scientific Research Instrumentation

Maintenance/Repair

Total expenditures for maintenance/repair of the current stock of academic research instruments were $304 million in 1992, an increase of 6 percent from the 1988–89 total of $287 million. This continues the trend of increases in total expenditures for maintenance/repair that began in 1982–83. However, the rate of increase has slowed and, in constant dollars, expenditures for maintenance/repair decreased by 8 percent between 1988–89 and 1992..

Expenditures for maintenance/repair include those for service contracts and field service, salaries of maintenance personnel, and other costs such as tools and supplies. Total expenditures for service contracts and field service were $146 million in 1992, a decline of 7 percent from the total expenditures of $157 million in 1988–89. In contrast, total expenditures for other maintenance-related activities, such as salaries and tools, increased from $130 million in 1988–89 to $158 million in 1992 (table B-5).

Median expenditures per unit for the maintenance of scientific research instrumentation declined in 1992 for the first time since the Instrumentation Survey began in 1982–83 (table B-6). Overall, the median expenditure for the maintenance/repair of scientific research instrumentation declined from $44,000 in 1988–89 to $33,000 in 1992, a decrease of 25 percent. The decline was evident in all units, whether department or facility, and in all types of expenses, whether service contracts and field service, or salaries and tools.

Operation

Total expenditures for the operation of scientific research instrumentation were $530 million in 1992, a decrease of 27 percent from 1988–89, the first time these data were collected in the survey (table B-5).

The bulk of expenditures in this category were for salaries for the technicians operating the instruments ($435 million). Other operating costs, such as outlays for supplies for operation, were $95 million (table 3).

The decline in the median expenditure per unit for the operation of research instruments was even greater than the decline of the median expenditure for maintenance/repair. The median expenditure for operation of scientific research instrumentation declined from $76,000 in 1988–89 to $40,000 in 1992 (47 percent).

Budget Allocations

Expenditures to maintain and operate the existing stock of scientific research instrumentation are an important additional cost that must be factored into the total instrumentation budget decisions by the head of every academic unit. In some S&E fields, the annual expenses for maintenance and operation of the existing stock of instrumentation actually exceeded the total cost of purchasing new instrumentation.

Academic departments and facilities spent $835 million on the combined costs to maintain and operate the existing stock of scientific research instrumentation in 1992. Overall, these expenditures equaled 61 percent of the total expenditures made to purchase new research instruments in 1992. That is, for every dollar spent to purchase new instrumentation, an additional $0.61 was spent on the maintenance/repair and operation of the stock of instrumentation in the unit (table B-7). (The expenditures to operate the research instruments were 39 percent of the expenditures to purchase research instruments, and the expenditures to maintain/repair research instruments were 22 percent of the cost of expenditures for new instrumentation.)

Table 3. Expenditures for maintenance/repair and operation of existing research instruments, by type of unit and field of science and engineering: 1992

[Dollars in millions]

Type of unit and expenditure	All fields	Engi-neering	Physical sciences	Environ-mental sciences	Computer scien:e	Agricul-tural sciences	Biolog-ical sciences	Other, multi-disci-plinary
All units:								
Total, maintenance/repair and operating costs	834	148	135	90	151	49	243	19
Total, maintenance/repair costs	304	60	56	26	64	10	81	6
Salaries of institution personnel	110	31	33	9	13	4	17	2
Other institution costs for servicing	48	12	9	3	12	3	9	2
Service contracts and field service	145	17	14	14	39	4	55	3
Total, operation of equipment	530	87	79	64	87	39	161	12
Salaries to operate equipme it	435	77	57	52	67	30	143	10
Other operating costs	95	10	22	13	21	9	18	2
Departments:								
Total, maintenance/repair and operating costs	488	78	89	39	25	42	208	1
Total, maintenance/repair costs	192	41	42	13	15	9	69	•
Salaries of institution personnel	71	22	22	6	4	3	13	•
Other institution costs for servicing	30	8	7	1	5	2	7	•
Service contracts and field service	90	11	12	6	7	3	49	•
Total, operation of equipment	296	37	48	26	11	33	138	•
Salaries to operate equipment	253	33	38	20	9	26	124	•
Other operating costs	42	4	10	5	2	8	14	•
Facilities:								
Total, maintenance/repair and operating costs	346	70	46	52	126	7	35	18
Total, maintenance/repair costs	112	19	15	13	49	1	12	6
Salaries of institution personnel	39	9	11	3	10	•	4	2
Other institution costs for servicing	18	4	2	1	7	•	2	2
Service contracts and field service	55	6	2	8	32	•	6	3
Total, operation of equipment	234	51	31	39	77	6	23	12
Salaries to operate equipment	182	44	19	31	58	5	19	10
Other operating costs	53	7	12	7	19	1	4	2

NOTE: Because of rounding, details may not add to totals.

KEY: • = Less than $500,000

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

The percentage of funds spent to maintain and operate research instrumentation varied considerably by field of science. For example, the academic unit heads in the agricultural sciences spent more to maintain and operate research instruments in 1992 than to purchase new research instruments: $1.22 was spent to maintain and operate existing research instruments for every dollar spent to purchase new instruments. Similarly, in computer science, $1.02 was spent to maintain and operate research instruments for every dollar spent to purchase instruments (table B-7).

At the low end of the proportion scale, $0.46 was spent in the physical sciences to maintain and operate research instruments for every dollar spent to purchase instruments. The comparable figure in engineering was $0.44 to maintain and operate research instruments for every dollar spent to purchase new instruments.

Capability, Needs, Amount, and Adequacy of Academic Scientific Research Instrumentation

Summary of Assessments of Current Stock of Instruments

In an attempt to assess the current stock of academic research instrumentation available to researchers, department chairs and heads of facilities were asked several questions concerning the ability of their instrumentation to fulfill the needs of their current faculty, the quality of the support services available to them, and the extent of their most pressing needs for instrumentation.

Several encouraging trends emerged from the responses. As shown in table 4, 68 percent of the department and facility heads reported that the amount of usable research equipment in their units had increased over the past 3 years. Forty-eight percent of the respondents reported that the adequacy of the research equipment had improved over this same period. An additional 34 percent reported that the adequacy of their equipment had remained the same Finally, 49 percent of the respondents reported that the instrumentation support services, such as those provided by the machine and electronics shops, were adequate; an additional 8 percent reported that these services were excellent (table B-8).

The responses regarding the *capability* of the research instrumentation presented a less positive view, however. Respondents were asked two questions designed to assess the capability of research instruments to support their units' faculties. First, they were asked to assess the *overall capability* of their units' research instruments to allow faculty investigators to pursue their major research interests; 31 percent of the respondents reported that the capability was insufficient (table 6). Second, they were asked to assess the *specific capability* of their units' research equipment to perform critical experiments; 56 percent of the unit heads reported that instruments in their units did not have the capability to allow current investigators to perform critical experiments in important subject areas (figure 3).

Finally, 79 percent of the respondents reported that their instrumentation needs over the past 3 years had increased (table 4). The total estimated cost of the three highest priority research instruments desired by the respondents was $2,730 million (table 5). In terms of the total cost to purchase research instruments, respondents reported that the greatest needs were for large, specialized research instruments (e.g., lasers, particle accelerators), computers, and spectrometers.

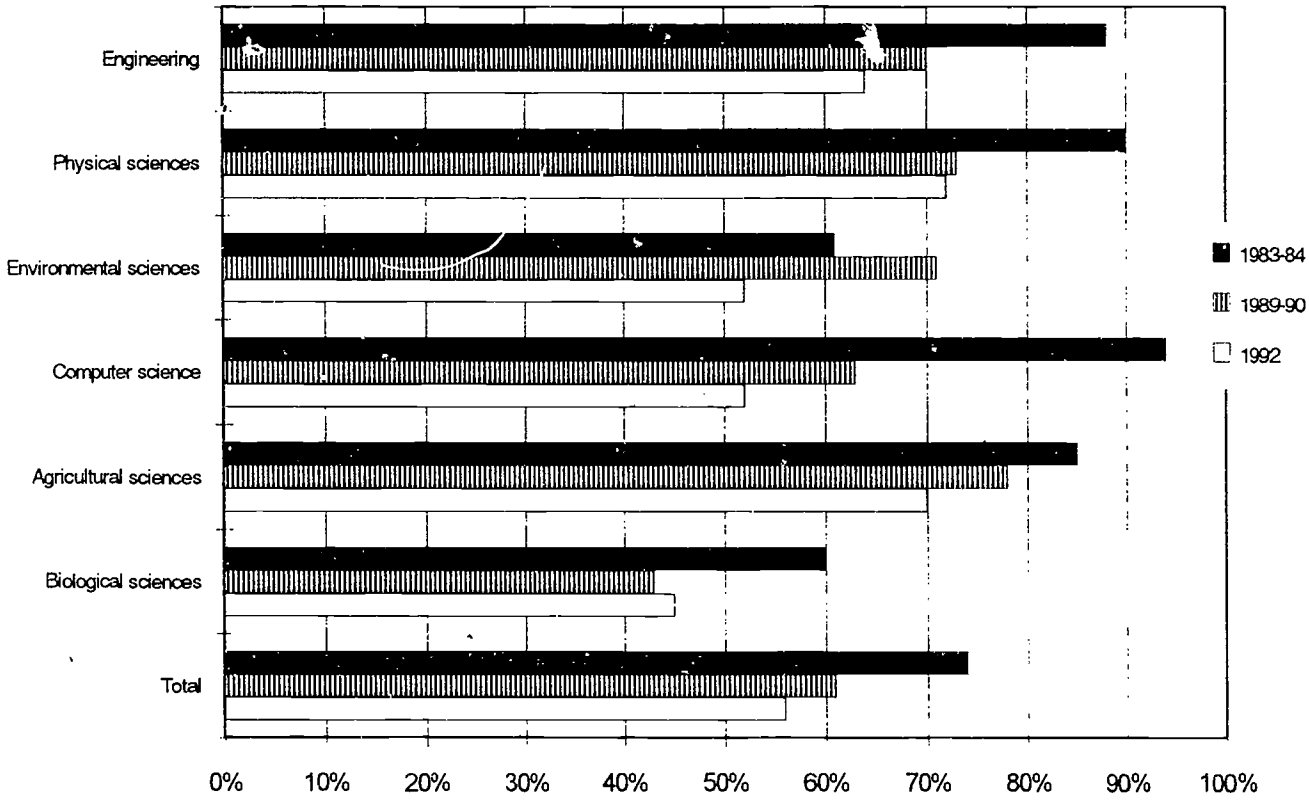
Amount of Usable Equipment

Respondents reported a general increase in the amount of usable research equipment on hand at their departments and facilities between 1989–90 and 1992. As shown in table 4, 53 percent reported that the amount of usable research equipment had increased; 15 percent reported that it had increased substantially (by 50 percent or more). Only 7 percent reported that the amount had decreased. For each S&E field, a majority of respondents reported that the amount of usable research equipment had increased.

Adequacy of Current Stock

A substantial proportion of respondents in each field of science reported that the adequacy of their research instrumentation had improved over the last 3 years (table 4). In computer science, 61 percent of the respondents reported that the adequacy of research instrumentation had improved. In engineering, environmental sciences, agricultural sciences, and the biological sciences, the modal, or most common response, was that the adequacy of research instrumentation had improved; the percentage of respondents that reported an improvement ranged from 47 to 48 percent for these fields. In only one field, the physical sciences, was the most common response that the adequacy of research equipment had remained the same. Overall, 48 percent of the respondents reported that the adequacy increased during the 3-year period 1988–92; 34 percent reported that it remained the same. In no field of science and engineering did a majority of respondents report that the adequacy of research instrumentation had declined.

Figure 3. Percentage of department/facility respondents reporting that their investigators cannot do critical experiments in their areas of research, due to lack of needed equipment, by field of science and engineering: 1983-92



SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Adequacy of Support Services

Respondents were asked to rate the adequacy of the support services available to them (e.g., machine shop, electronics shop). The majority of respondents reported that instrumentation support services were adequate (49 percent) or excellent (8 percent) (table B-8).

On the other hand, 28 percent reported that these services were insufficient, and an additional 9 percent reported that they did not have support services at all, although they were needed (table B-8). Respondents in the agricultural and environmental sciences were most likely to respond in these two categories signifying inadequacy of services; 57 percent of the agricultural unit heads and 50 percent of the environmental unit heads reported either that their support services were inadequate for their needs or that there were no support services at all even though the need was there.

Perceived Limitations of Instrumentation

Respondents were asked to assess the research instrumentation in their departments or facilities in terms of its capability to enable faculty investigators to pursue their major research interests. Although 53 percent of the unit heads reported that their research instruments were adequate for this purpose, 31 percent reported that their research instruments were insufficient. Only 16 percent rated their instruments as excellent (table 6).

Table 4. Perceived change over the past 3 years in instrument needs, amount of usable instruments, and adequacy of academic research instruments, by field of science and engineering: 1992

[In percent]

Perceived instrument trends over the past 3 years	All fields	Engineering	Physical sciences	Environmental sciences	Computer science	Agricultural sciences	Biological sciences	Other, multidisciplinary
All units:								
Percentage of respondents who reported that instrument needs had--								
Increased	79	78	79	74	63	77	86	76
Remained the same	18	18	19	18	32	20	13	24
Decreased	3	4	3	9	6	4	1	0
Percentage of respondents who reported that the amount of usable equipment had--								
Increased 50% or more	15	12	13	19	23	8	16	7
Increased 11-49%	53	54	59	53	38	57	51	55
Remained the same +/- 10%	26	24	26	23	33	23	27	38
Decreased 11-49%	7	9	3	4	5	11	7	0
Decreased 50% or more	0	1	0	1	1	0	0	0
Percentage of respondents who reported that the adequacy of equipment had--								
Improved	48	48	42	47	61	48	47	67
Remained the same	34	35	44	37	27	21	34	30
Declined	18	17	15	16	12	31	19	3

NOTE: Because of rounding, percentages may not add to 100.

KEY: * = Insufficient number of cases for analysis

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table 5. Total cost for the highest priority item requested, and total cost for the three top priority items requested, by type of unit and field of science and engineering: 1992

[Dollars in millions]

Type of unit and field of science and engineering	Total cost of first priority item	Total cost of the three top priority items
All units	1,202	2,730
Engineering	231	582
Physical sciences	385	675
Environmental sciences	80	231
Computer science	230	573
Agricultural sciences	23	58
Biological sciences	231	563
Other, multidisciplinary	21	48
Departments	637	1,677
Engineering	146	415
Physical sciences	211	396
Environmental sciences	58	154
Computer science	32	215
Agricultural sciences	19	49
Biological sciences	169	446
Other, multidisciplinary	1	1
Facilities	565	1,053
Engineering	85	169
Physical sciences	174	278
Environmental sciences	22	76
Computer science	198	358
Agricultural sciences	4	9
Biological sciences	61	117
Other, multidisciplinary	20	47

NOTE: Because of rounding, details may not add to totals.

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Respondents also were asked if investigators in their departments or facilities were unable to perform critical experiments in their areas of research interest due to a lack of needed equipment. In 1992, slightly more than half of all respondents (56 percent) reported that there were subject matters in which investigators could not perform critical experiments because needed equipment was lacking (figure 3). However, since 1983–84 there has been a steady decline in the percentage of respondents who report this limitation. In 1983–84, 74 percent of the department/facility heads reported such limitations; in 1989–90, the percentage declined to 61 percent.

This percentage had decreased for all fields of science between 1983–84 and 1992. The greatest decrease occurred in computer science. In 1983–84, 94 percent of all respondents in computer science reported that there were subject matters in which investigators in their units were unable to perform critical experiments because needed instrumentation was lacking. In 1992, this percentage was 52 percent.

Thus, while there has been steady improvement in the availability of critical research instrumentation, the continued lack of specific equipment is an important limitation for the scientific community. This lack of

Table 6. Capability of academic research instruments to enable faculty to pursue major research interests, by type of unit and field of science and engineering: 1992

[In percent]

Type of unit and field of science and engineering	Excellent	Adequate	Insufficient
All units	16	53	31
Engineering	12	48	40
Physical sciences	11	50	39
Environmental sciences	15	55	31
Computer science	13	56	30
Agricultural sciences	6	51	44
Biological sciences	22	58	21
Other, multidisciplinary fields	65	17	18
Departments	14	52	34
Engineering	11	46	43
Physical sciences	9	52	38
Environmental sciences	15	50	35
Computer science	9	55	36
Agricultural sciences	5	48	47
Biological sciences	21	57	22
Other, multidisciplinary fields	*	*	*
Facilities	23	55	22
Engineering	17	59	24
Physical sciences	19	40	39
Environmental sciences	14	64	22
Computer science	17	58	25
Agricultural sciences	8	66	26
Biological sciences	27	63	11
Other, multidisciplinary fields	68	15	17

NOTE: Because of rounding, percentages may not add to 100.

KEY: * = Insufficient number of cases for analysis

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

needed equipment was reported by a majority of respondents in all fields of science, except for biology. Slightly less than half of the respondents in the biological sciences, 45 percent, reported that their investigators could not perform critical experiments due to a lack of needed equipment. The greatest problems were reported by respondents in the physical sciences (72 percent) and in the agricultural sciences (70 percent).

TYPES, COST, AND NEED FOR HIGH-PRIORITY INSTRUMENTATION

Three Top-Priority Items

Department chairs and heads of facilities were asked to identify the three pieces of research instrumentation, with a purchase price of $20,000 or more, that were the "topmost priorities" in their units. They were asked to list these items in priority order, to estimate the purchase price of each top priority

instrument, and to state the reason it was needed. The total estimated purchase price of all three top priority items was $2,730 million (table 5). Of this total, an estimated $1,202 million was for first priority research equipment only.

First Priority Items

Respondents have a preference for more expensive research equipment. That is, the total estimated purchase price of first priority items, $1,202 million, was 44 percent of the total estimated purchase price of all three items, $2,730 million.

The greatest need for research instruments, in terms of total purchase price, was for computers (table B-9). The total estimated purchase price of those computers that were identified as the respondents' first priority was $301 million, 25 percent of the total for all first priority items. The bulk of this money, $229 million, was requested by respondents in computer science units. In no other field of science were expenditures for computers the principal cost of all first priority items.

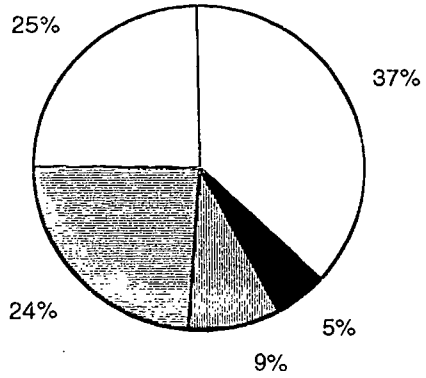
Spectrometers (e.g., electron spectrometer/surface analyzer, gas chronometer/mass spectrometer), with an estimated total purchase price of $294 million, were the second most frequently identified top priority research instruments, as measured by estimated total purchase price (table B-9). Spectrometers were the most expensive type of equipment requested.

The third most frequently mentioned class of research instrument was the microscope (e.g., electron microscope, photomicroscope, microprojector/ microscope), comprising 9 percent of the total (figure 4).

Finally, many respondents indicated an important requirement for large, highly specialized pieces of research equipment, such as wind tunnels, lasers, cyclotrons, and particle accelerators. These pieces of equipment are often specially developed, "one-of-a-kind" instruments or are prototypes. For purposes of analysis, they are categorized as "other" research instruments. The estimated total purchase price of these pieces of research equipment was $439 million, 37 percent of the total (table B-9).

These large, specialized pieces of research equipment were most frequently requested by respondents in the fields of engineering and the physical sciences. As shown in table B-9, the total cost of all "other" instruments in engineering was $117 million; in the physical sciences it was $260 million. These two fields of science accounted for 86 percent of the total expenditures for "other" research equipment. The median cost of these pieces of equipment also was quite high. For example, the

Figure 4. Distribution of total cost of highest priority academic research instruments, by type of instrument: 1992



SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

median cost of "other" instruments in physical science facilities was $400,000. The median for "other" instruments in all facilities was $100,000 (table B-10).

As would be expected, there was considerable variation in the estimated purchase prices among categories of the first priority equipment. For example, the median purchase price for desired spectrometers was $221,000. The median purchase price for computers was $75,000 (table B-10).

There also was considerable variation in cost within a category of equipment, depending upon its intended use. The median price of a first priority computer identified by computer science respondents was $150,000; the median price of a first priority computer in engineering was $57,000. The most expensive spectrometers were requested by unit heads in the physical sciences—a median estimated purchase price $375,000—and the environmental sciences—a median estimated purchase price $262,500. In comparison, the median estimated price of a spectrometer in the agricultural sciences was $120,000 (table B-10).

Reasons Needed

In all fields of science and engineering, respondents reported that the primary reason they needed the top priority research instrument was to "upgrade capabilities" for the unit, i.e., to perform experiments that they "cannot do now." Indeed, for four of the seven fields, more than half of all respondents gave this as the primary reason for need (figure 5). This supports the finding, noted above, that 56 percent of the unit heads reported that there were subject matters in which investigators in their departments or facilities could not perform critical experiments because needed equipment was lacking (figure 3). The reason cited least often was to replace existing equipment, equipment that may have become obsolete or was worn out.

Optimal Price Range of Federal Funding

When asked the price range where Federal funding would be most beneficial to the research in their units, respondents reported a relatively greater need for less expensive equipment (i.e., items with a purchase price of less than $50,000). In 1992, 55 percent of the respondents reported that if greater Federal funding were available, the price range of the equipment most beneficial to their units would be less than $50,000. In contrast, the majority of respondents in the 1989–90 survey (53 percent) reported that increased funding for research equipment costing $50,000 or more would be most beneficial to their units (table B-11). The findings in 1992 returned to the pattern set in the 1983–84 and 1986–87 surveys when a majority of the respondents reported that instruments with a purchase price of $50,000 or less would be most beneficial.

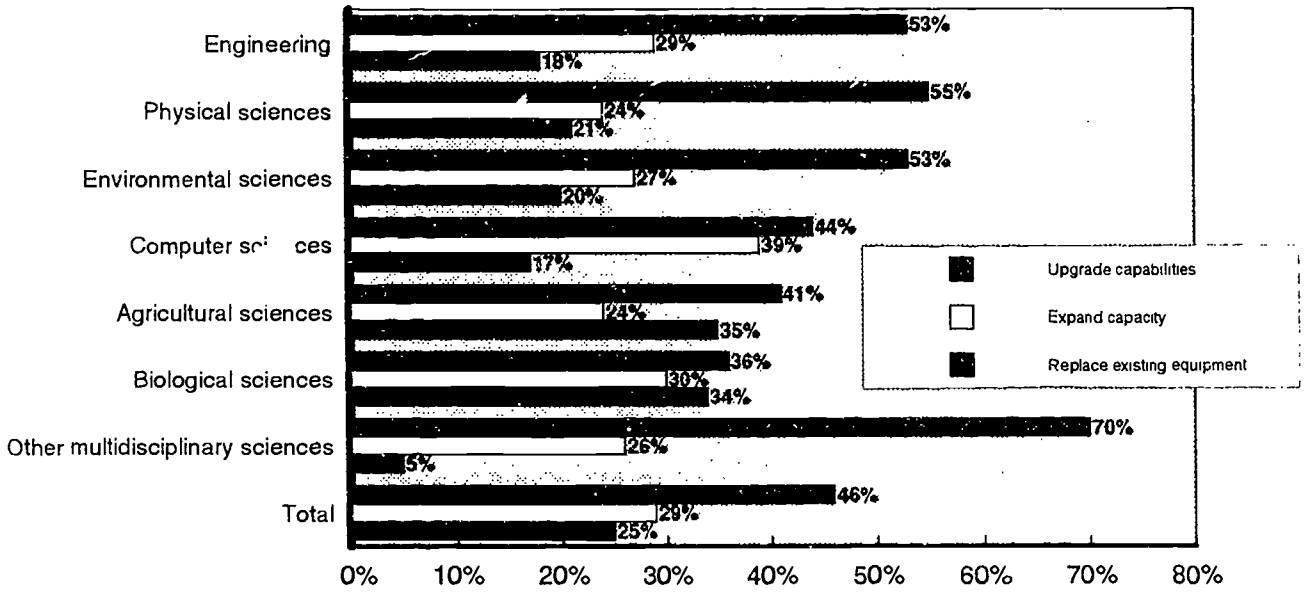
Respondents in the physical sciences reported the greatest proportion of needs for the more expensive equipment: 69 percent reported a need for equipment over $50,000 (table B-11). Yet, even in this discipline, which is characterized by high-priced equipment, the proportion needing the most expensive equipment declined since the last survey (81 percent favored the equipment over $50,000 in 1989–90).

There was also a decrease in the proportion of computer science respondents who thought that the top costing instruments would be the most beneficial price range—from 73 to 56 percent. Of all fields surveyed, only respondents from the environmental sciences reported an increase in their need for the higher-priced instruments, from 55 percent wanting the upper-end instruments in 1988–89 to 58 percent in 1992.

These results do not contradict the findings reported above that the first priority of respondents is for higher-priced equipment: the requirement for high-priced equipment varies by field of science. Therefore, the optimal price range for Federal funding for research instrumentation must be determined for each field of science. For some programs, such as biology and agriculture, to purchase less expensive research instruments may be extremely effective. In other programs, such as the physical sciences, to purchase more expensive research instruments may be more beneficial.

Variations in the requirements for high-priced research instruments may be seen in table B-11: The agricultural and biological sciences tend to require relatively less expensive research instruments; engineering and the physical sciences tend to require relatively more expensive research instruments. Specifically, 69 percent of the respondents in the physical sciences and 58 percent of the respondents in the environmental sciences reported that increased

Figure 5. Reason for need for the highest priority research instrument, by field of science and engineering: 1992



SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Federal funding for instruments in the $50,000 and above range would be most beneficial. In contrast, only 30 percent of the respondents in biology and 19 percent of the respondents in agriculture reported that increased Federal funding for instruments in the $50,000 and above range would be most beneficial.

APPENDIX A
AN ANALYSIS OF COMPUTER SCIENCE EXPENDITURES FOR THE PURCHASE OF ACADEMIC SCIENTIFIC RESEARCH INSTRUMENTATION

The estimates of expenditures for the purchase of research instrumentation by computer science departments and facilities were based upon samples of academic units selected in each cycle. Because there was a large decline in computer science expenditures for research instrumentation in the 1992 (Cyc IV) survey, two supplemental analyses of the samples of computer science units selected in Cycle III (1988 for computer sciences) and in 1992 were conducted in order to understand the data more fully. The first analysis replicated the population findings with data taken from a panel of 67 units that were found in the samples for both 1988 and 1990. The second analysis compared the characteristics of the sample of computer science facilities selected in 1988 and the sample selected in 1992 to determine if important changes had occurred that might influence these trends.

Panel Analysis

In 1988, data were collected from 110 units in computer science (38 departments and 72 facilities). In 1992, data were collected from 85 units (43 departments, 42 facilities). Of these, 67 units (30 departments, 37 facilities) were in both 1988 and 1992 and also met the increased purchase price criterion of $20,000. These 67 units may be considered to be a panel. The purpose of the panel analysis was to determine if the general trends found for the sample could be replicated in the panel. It was not necessary for the magnitudes of change to be replicated, only for the direction of change to be supported.

This panel analysis had three principal results: It provided general support for the direction of the trends in expenditures found in the analysis of the samples of computer science units for 1988 and 1992; it supported the specific proposition that the decline in expenditures for the purchase of research instruments was confined to computer science facilities; and it differed in the magnitude of these changes in expenditures.

[1] A department is an institutional unit that awards academic degrees and has faculty assigned to it. A facility is an institutional unit that does not award academic degrees and does not have faculty assigned to it. Unit is a generic term that includes both departments and facilities.

As shown in table A-1, the total annual expenditures for the purchase of instrumentation by the 67 computer science units in the panel declined by 6 percent between 1988 and 1992. Total expenditures for the survey sample declined by 35 percent (table 1). Median expenditures per unit declined by 12 percent for the panel (table A-1) and by 49 percent for the survey sample (table B-1).

Table A-1. Expenditures for the purchase of academic research instruments, panel of 67 computer science units: 1988 and 1992

[Dollars in thousands]

Year and type	All units	Depart-ments	Facili-ties
1988:			
Total	138,373	28,158	110,215
Median	330	200	642
1992:			
Total	130,014	47,128	82,976
Median	291	300	283

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Both total expenditures and median expenditures for the purchase of scientific research instrumentation increased for the sample of departments and for the panel of departments. Total expenditures for the survey sample of departments increased by 59 percent (table 1); total expenditures for the panel increased by 68 percent (table A-1). Median expenditures per unit increased by 50 percent for the panel (table A-1) and by 22 percent for the survey sample (table B-1).

Total and median expenditures for the purchase of research instrumentation declined for both the sample of facilities and for the panel of facilities. Total expenditures for the survey sample declined by 51 percent; total expenditures for the panel declined by 25 percent (tables 1 and A-1). Median expenditures per unit declined by 56 percent for the panel and by 61 percent for the survey sample (tables A-1 and B-1).

Comparison of the Samples of Computer Science Facilities

The analysis of both the sample and the panel data supports the proposition that the decline in computer science expenditures for equipment between 1988 and 1992 was confined to the computer science facilities. Therefore, a second analysis was conducted to determine if this decline might be caused by changes in the composition of the samples of computer science facilities between the two cycles.

This analysis suggested that the samples of computer science facilities had changed considerably between 1988 and 1992. First, the sample of facilities in 1992 was almost 30 percent smaller than the sample in 1988. Second, many of the eligible facilities in 1988 were found to be ineligible in 1992. The principal reason for ineligibility was that the computer at the facility was no longer used for research.

As already noted, there were 72 computer science facilities in the sample selected in 1988. Of these, 51 were also included in 1992, either as respondents or as nonrespondents. Two units, each classified as a facility in 1988, were classified as a department in 1992. Nineteen facilities were ineligible for the survey (out-of-scope) in 1992 for the following reasons:

Number	Reason
10	Computer facility not used for research in Cycle IV
3	Closed
3	No equipment with a purchase price of $20,000 or more
1	Merged with another computer science facility
2	Reason unknown
19	Total

It was not possible to determine if the 10 facilities that did not conduct research in 1992 had been misclassified in 1988 or whether the scope of their work had changed just since 1988. However, this does suggest that the decline in expenditures for the purchase of equipment is related to a change in the academic mission of the computers at these facilities. There simply are fewer large centralized computer facilities devoted to research.

This interpretation is supported by the fact that there appear to be fewer large centralized computer facilities overall. In 1992, 58 computer science facilities were found to be eligible for inclusion in the survey. This includes seven new computer facilities added to the sample in 1992. However, the total number of facilities included in the analysis declined by 24 percent between 1988 and 1992. This decline certainly contributed to the decline in total expenditures for the purchase of equipment.

The Instrumentation Survey does not collect data that may be used directly to assess the reasons for this decline in the number of centralized computer facilities. However, during the last few years the development of relatively inexpensive, powerful computers such as work stations and minicomputers has reduced the need for large mainframe computers. (Many of these less expensive computers cost less than $20,000, the minimum necessary for inclusion in the Instrumentation Survey.) Researchers are installing the smaller computers in their laboratories and offices, making computer access more responsive to their needs. The offices and laboratories are in departments and facilities for chemistry, agriculture, biology, physics, and engineering—not computer science. Therefore, purchases of computers used for research would be reported as expenditures for these disciplines and not as computer science expenditures.

APPENDIX B

TABLES

Table B-1. Median annual expenditures per unit for the purchase of academic research instruments, by type of unit and field of science and engineering: 1982-83 to 1992

[Dollars in thousands]

Type of unit and field of science and engineering	1982-83	1985-86	1988-89	1992
All units	93	164	168	150
Engineering	99	199	168	150
Physical sciences	241	300	347	437
Environmental sciences	76	147	101	130
Computer science	168	383	490	250
Agricultural sciences	58	107	131	95
Biological sciences	80	142	152	132
Other, multidisciplinary fields	111	111	102	126
Departments	93	168	165	153
Engineering	84	199	184	163
Physical sciences	260	300	372	461
Environmental sciences	76	147	97	136
Computer science	164	383	200	244
Agricultural sciences	59	103	125	100
Biological sciences	83	150	164	150
Other, multidisciplinary fields	*	*	*	*
Facilities	95	141	173	116
Engineering	309	127	130	100
Physical sciences	155	383	287	362
Environmental sciences	88	148	125	125
Computer science	474	402	642	250
Agricultural sciences	54	168	157	33
Biological sciences	63	92	103	72
Other, multidisciplinary fields	111	111	100	123

NOTES: Years 1982-83 and 1985-86 do not contain supersystems (units having an integrated instrument system with a purchase price of generally $1,000,000 or more).

KEY: * = Insufficient number of cases for analysis

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-2. Funds for purchase of academic research instruments as a percent of total expenditures for purchase of academic research instruments, by source of funds, type of unit, and field of science and engineering: 1982-83 to 1992

[In percent]

Type of unit, field of science and engineering, and source of funds	1982-83	1985-86	1988-89	1992
All units:				
All fields:				
Federal funds	51	50	.	48
Non-Federal funds	49	50	.	52
Engineering:				
Federal funds	47	43	.	39
Non-Federal funds	53	57	.	61
Physical sciences:				
Federal funds	66	65	.	68
Non-Federal funds	34	35	.	32
Environmental sciences:				
Federal funds	43	47	.	61
Non-Federal funds	58	53	.	39
Computer science:				
Federal funds	49	40	.	16
Non-Federal funds	51	60	.	84
Agricultural sciences:				
Federal funds	25	24	.	27
Non-Federal funds	75	76	.	73
Biological sciences:				
Federal funds	48	54	.	49
Non-Federal funds	52	46	.	51
Other, multidisciplinary fields:				
Federal funds	67	40	.	49
Non-Federal funds	33	60	.	51
Departments:				
All fields:				
Federal funds	50	50	.	50
Non-Federal funds	50	50	.	50
Engineering:				
Federal funds	44	40	.	39
Non-Federal funds	56	60	.	61
Physical sciences:				
Federal funds	65	63	.	65
Non-Federal funds	35	37	.	35
Environmental sciences:				
Federal funds	37	51	.	64
Non-Federal funds	65	49	.	36
Computer science:				
Federal funds	44	35	.	32
Non-Federal funds	56	65	.	68
Agricultural sciences:				
Federal funds	27	26	.	26
Non-Federal funds	73	74	.	74
Biological sciences:				
Federal funds	49	54	.	51
Non-Federal funds	51	46	.	49
Other, multidisciplinary fields:				
Federal funds	0	0	.	43
Non-Federal funds	0	0	.	57

See explanatory information and SOURCE at end of table.

Table B-2. Funds for purchase of academic research instruments as a percent of total expenditures for purchase of academic research instruments, by source of funds, type of unit, and field of science and engineering: 1982-83 to 1992

[In percent]

Type of unit, field of science and engineering, and source of funds	1982-83	1985-86	1988-89	1992
Facilities:				
All fields:				
Federal funds	54	54	*	41
Non-Federal funds	46	46	*	59
Engineering:				
Federal funds	68	65	*	41
Non-Federal funds	32	35	*	59
Physical sciences:				
Federal funds	78	80	*	83
Non-Federal funds	22	20	*	17
Environmental sciences:				
Federal funds	53	33	*	57
Non-Federal funds	47	67	*	43
Computer science:				
Federal funds	95	62	*	6
Non-Federal funds	5	38	*	94
Agricultural sciences:				
Federal funds	22	13	*	38
Non-Federal funds	78	87	*	62
Biological sciences:				
Federal funds	29	52	*	33
Non-Federal funds	71	48	*	67
Other, multidisciplinary fields:				
Federal funds	67	40	*	49
Non-Federal funds	33	60	*	51

NOTES: Because of rounding, percentages may not add to 100.

Years 1982-83 and 1985-86 do not contain supersystems (units having an integrated instrument system with a purchase price of generally $1,000,000 or more).

KEY: * = Data were not collected in that survey year.

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-3. Percent of funds for purchase of academic research instruments, by source of funds: 1992

[In percent]

Source of funds	Total
Total	100
Federal, total	48
National Science Foundation	14
National Institutes of Health	14
Department of Defense	6
Department of Energy	7
Department of Agriculture	1
Other	6
Non-Federal, total	52
Institution funds	24
State and local governments	12
Private, nonprofit organizations	7
Industry	8
Other	2

NOTE: Because of rounding, percentages may not add to 100.

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-4. Expenditures for purchase of academic research instruments as a percent of total R&D expenditures, by field of science and engineering: 1982-83 to 1992

[In percent]

Field of science and engineering	1982-83	1985-86	1988-89	1992
All units	8	12	13	12
Engineering	9	14	13	12
Physical sciences	11	17	15	15
Environmental sciences	6	8	7	12
Computer science	12	21	57	27
Agricultural sciences	3	3	4	3
Biological sciences	11	12	11	13

NOTES: Years 1982-83 and 1985-86 do not contain supersystems (units having an integrated instrument system with a purchase price of generally $1,000,000 or more).

Total R&D expenditures for 1982, 1985, 1989, and 1991 were obtained from the Survey of R&D Expenditures at Universities and Colleges, fiscal year 1991, National Science Foundation.

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-5. Expenditures for maintenance/repair and operation of existing academic research instruments, by type of unit: 1982-83 to 1992

[Dollars in millions]

Type of unit and expenditure	1982-83	1985-86	1988-89	1992
All units:				
Total, maintenance/repair and operating costs	*	*	1,010	835
Total, maintenance/repair	101	143	267	304
Service contracts and field service	*	68	157	146
Other (salaries, tools, etc.)		75	130	158
Total, operation (supplies, technician salaries, etc.)	*	*	723	530
Departments:				
Total, maintenance/repair and operating costs	*	*	442	482
Total, maintenance/repair	85	118	142	189
Service contracts and field service	34	58	72	88
Other (salaries, tools, etc.)	51	60	70	101
Total, operation (supplies, technician salaries, etc.)	*	*	300	292
Facilities:				
Total, maintenance/repair and operating costs	*	*	568	353
Total, maintenance/repair	16	25	145	115
Service contracts and field service	8	10	85	58
Other (salaries, tools, etc.)	8	15	60	57
Total, operation (supplies, technician salaries, etc.)	*	*	423	238

NOTE: Years 1982-83 and 1985-86 do not contain supersystems (units having an integrated instrument system with a purchase price of generally $1,000,000 or more).

KEY: * = Not ascertained in that survey year

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-6. Median expenditures for maintenance/repair and operation of existing academic research instruments, by type of unit: 1982-83 to 1992

[Dollars in thousands]

Type of unit and expenditure	1982-83	1985-86	1988-89	1992
All units:				
Total, maintenance/repair and operating costs	*	*	135	85
Total, maintenance/repair	24	36	44	33
Service contracts and field service	10	15	20	14
Other (salaries, tools, etc.)	10	12	18	12
Total, operation (supplies, technician salaries, etc)	*	*	76	40
Departments:				
Total, maintenance/repair and operating costs	*	*	110	76
Total, maintenance/repair	23	36	40	32
Service contracts and field service	10	15	18	14
Other (salaries, tools, etc.)	9	13	15	11
Total, operation (supplies, technician salaries, etc.)	*	*	54	33
Facilities:				
Total, maintenance/repair and operating costs	*	*	252	129
Total, maintenance/repair	28	35	62	42
Service contracts and field service	13	10	22	13
Other (salaries, tools, etc.)	15	10	24	13
Total, operation (supplies, technician salaries, etc.)	*	*	139	71

NOTE: Years 1982-83 and 1985-86 do not contain supersystems (units having an integrated instrument system with a purchase price of generally $1,000,000 or more).

KEY: * = Not ascertained in that survey year

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-7. Expenditures for maintenance/repair and operation of stock of existing academic research instruments as a percent of expenditures for purchase of additional academic research instruments, by type of unit and field of science and engineering: 1992

[In percent]

Type of unit and field of science and engineering	Maintenance/ repair	Operation	Total maintenance/ repair/ operation
All units	22	39	61
Engineering	18	26	44
Physical sciences	19	27	46
Environmental sciences	20	49	69
Computer science	43	59	102
Agricultural sciences	25	97	122
Biological sciences	21	42	63
Other, multidisciplinary fields	19	38	57
Departments	18	28	47
Engineering	15	13	28
Physical sciences	17	19	36
Environmental sciences	19	38	58
Computer science	28	20	47
Agricultural sciences	24	93	117
Biological sciences	20	39	59
Other, multidisciplinary fields	34	18	52
Facilities	34	72	106
Engineering	33	88	120
Physical sciences	32	68	101
Environmental sciences	20	60	80
Computer science	52	82	134
Agricultural sciences	36	125	160
Biological sciences	32	62	94
Other, multidisciplinary fields	19	38	57

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-8. Adequacy of support services for academic research instruments, by type of unit and field of science and engineering: 1992

[In percent]

Type of unit and field of science and engineering	Excellent	Adequate	Insufficient	Nonexistent but needed	Nonexistent and not needed
All units	8	49	28	9	5
Engineering	6	58	32	2	2
Physical sciences	8	55	34	2	1
Environmental sciences	5	41	36	14	5
Computer science	9	47	16	11	16
Agricultural sciences	4	28	36	21	10
Biological sciences	12	47	23	12	7
Other, multidisciplinary fields	9	58	25	3	5
Departments	8	48	31	10	4
Engineering	7	57	34	2	1
Physical sciences	7	53	36	3	1
Environmental sciences	6	33	37	17	6
Computer science	3	59	21	16	0
Agricultural sciences	0	28	38	24	9
Biological sciences	11	46	25	13	6
Other, multidisciplinary fields	*	*	*	*	*
Facilities	11	52	21	5	11
Engineering	4	61	25	3	7
Physical sciences	12	63	23	0	2
Environmental sciences	4	54	32	8	1
Computer science	14	36	12	7	31
Agricultural sciences	25	28	25	8	13
Biological sciences	19	50	14	4	12
Other, multidisciplinary fields	9	59	23	3	6

NOTE: Because of rounding, percentages may not add to 100.

KEY: * = Insufficient number of cases for analysis

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-9. Total cost and percent of total for the highest priority item requested, by type of instrument, type of unit, and field of science and engineering: 1992

[Dollars in millions]

Type of unit and field of science and engineering	All instruments		Computers		Spectrometers		Microscopes		Bioanalytical instruments		Other instruments	
	Total cost	Percent of total	Total cost	Percent of total	Total cost	Percent of total	Total cost	Percent of total	Total cost	Percent of total	Total cost	Percent of total
All units	1,202	100	301	25	294	24	113	9	55	5	439	37
Engineering	231	19	34	3	39	3	35	3	6	0	117	10
Physical sciences	385	32	5	0	116	10	3	0	1	0	260	22
Environmental sciences	80	7	10	1	38	3	11	1	0	0	20	2
Computer science	230	19	229	19	0	0	0	0	0	0	2	0
Agricultural sciences	23	2	2	0	5	0	1	0	8	1	6	1
Biological sciences	231	19	18	1	88	7	56	5	40	3	29	2
Other, multidisciplinary	21	2	3	0	7	1	6	0	0	0	6	0
Departments	637	53	77	6	211	18	92	8	45	4	212	18
Engineering	146	12	18	1	27	2	30	2	3	0	69	6
Physical sciences	211	18	5	0	103	9	2	0	0	0	101	8
Environmental sciences	58	5	4	0	28	2	11	1	0	0	15	1
Computer science	32	3	31	3	0	0	0	0	0	0	0	0
Agricultural sciences	19	2	2	0	5	0	1	0	7	1	4	0
Biological sciences	169	14	16	1	48	4	49	4	34	3	23	2
Other, multidisciplinary	1	0	1	0	0	0	0	0	0	0	0	0
Facilities	565	47	224	19	82	7	21	2	11	1	228	19
Engineering	85	7	17	1	12	1	5	0	3	0	48	4
Physical sciences	174	14	0	0	12	1	2	0	1	0	159	13
Environmental sciences	22	2	6	1	10	1	1	0	0	0	5	0
Computer science	198	17	197	17	0	0	0	0	0	0	2	0
Agricultural sciences	4	0	0	0	1	0	0	0	1	0	2	0
Biological sciences	61	5	2	0	40	3	7	1	5	0	7	1
Other, multidisciplinary	20	2	2	0	7	1	6	0	0	0	6	0

NOTE: Because of rounding, details may not add to totals.

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-10. Median cost of the highest priority item requested and percent of respondents requesting that item, by type of instrument, type of unit, and field of science and engineering: 1992

[Dollars]

Type of unit and engineering	All Instruments		Computers		Spectrometers		Microscopes		Bioanalytical instruments		Other instruments	
	Median cost	Percent of total	Median cost	Percent of total	Median cost	Percent of total	Median cost	Percent of total	Median cost	Percent of total	Median cost	Percent of total
All units	88,000	100	75,000	22	221,000	20	180,000	10	40,000	19	88,000	28
Engineering	100,000	100	57,000	19	100,000	19	450,000	7	39,000	6	100,000	50
Physical sciences	200,000	100	90,000	9	375,000	52	110,000	4	*	1	140,000	33
Environmental sciences	100,500	100	41,500	24	262,500	33	325,000	7	*	1	72,141	35
Computer science	200,000	100	150,000	99	*	0	*	0	*	0	*	1
Agricultural sciences	49,000	100	50,000	6	120,000	16	87,500	3	40,000	49	50,000	25
Biological sciences	60,000	100	70,000	15	250,000	14	147,500	18	45,000	39	50,000	14
Other, multidisciplinary	175,000	100	70,000	23	425,000	20	205,000	23	50,000	2	100,000	33
Departments	80,000	100	70,000	19	200,000	21	150,000	11	40,000	22	83,600	28
Engineering	90,000	100	50,000	17	86,398	19	475,000	7	35,000	6	100,000	51
Physical sciences	200,000	100	100,000	9	400,000	58	100,000	4	*	0	100,000	28
Environmental sciences	100,000	100	38,000	22	250,000	35	250,000	10	*	0	72,500	33
Computer science	130,000	100	126,000	99	*	0	*	0	*	0	*	1
Agricultural sciences	48,000	100	60,000	7	120,000	15	100,000	4	40,000	57	50,000	17
Biological sciences	55,000	100	85,000	15	222,500	12	150,000	19	42,000	41	45,000	14
Other, multidisciplinary	60,000	100	*	0	*	0	*	0	*	0	*	0
Facilities	120,000	100	100,000	35	240,000	19	235,000	6	80,000	10	100,000	29
Engineering	148,000	100	75,000	28	140,000	16	450,000	3	111,500	8	200,000	45
Physical sciences	150,000	100	45,000	10	120,000	15	500,000	7	175,000	5	400,000	63
Environmental sciences	100,000	100	60,000	29	300,000	30	*	1	*	2	72,141	38
Computer science	250,000	100	200,000	99	*	0	*	0	*	0	*	1
Agricultural sciences	65,000	100	*	2	55,000	19	*	2	120,000	15	56,000	61
Biological sciences	90,000	100	40,000	15	300,000	30	130,000	12	80,000	32	82,500	11
Other, multidisciplinary	188,000	100	55,000	21	425,000	20	205,000	24	*	2	150,000	32

NOTE: Because of rounding, percentages may not add to 100.

KEY: * = Insufficient number of cases for analysis

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

Table B-11. Percent of respondents identifying instruments in the $50,000 and above range as being the area where increased Federal funding would be most beneficial, by type of unit and field of science and engineering: 1983-84 to 1992

[In percent]

Type of unit and field of science and engineering	1983-84	1986-87	1989-90	1992
All units	27	37	53	45
Engineering	31	33	60	50
Physical sciences	45	54	81	69
Environmental sciences	38	44	55	58
Computer science	26	27	73	56
Agricultural sciences	8	23	25	19
Biological sciences	20	35	32	30
Other, multidisciplinary fields	47	46	81	72
Departments	27	35	48	41
Engineering	30	32	59	45
Physical sciences	45	56	79	65
Environmental sciences	45	43	61	64
Computer science	29	20	57	40
Agricultural sciences	8	24	24	20
Biological sciences	20	34	29	28
Other, multidisciplinary fields	*	*	*	*
Facilities	31	45	68	58
Engineering	52	43	63	69
Physical sciences	41	33	89	86
Environmental sciences	24	49	43	47
Computer science	0	68	81	69
Agricultural sciences	12	8	38	15
Biological sciences	19	46	52	42
Other, multidisciplinary fields	47	47	80	71

NOTE: Years 1982-83 and 1985-86 do not include supersystems (units having an integrated instrument system with a purchase price of generally $1.000,000 or more).

KEY: * = Insufficient number of cases for analysis

SOURCE: National Science Foundation/SRS, Survey of Academic Research Instruments and Instrumentation Needs: 1992

APPENDIX C
LIST OF SAMPLED INSTITUTIONS

Nonmedical Colleges and Universities

Brown University
California Institute of Technology
Colorado State University
Cornell University
Duke University
Georgia Institute of Technology
Harvard University
Johns Hopkins University
Louisiana State University
Massachusetts Institute of Technology
Michigan State University
Mississippi State University
New Mexico Institute of Mining and Technology
North Carolina State University
Northeastern University
Northwestern University
Ohio State University
Oklahoma State University
Oregon State University
Pennsylvania State University
Princeton University
Purdue University
Rockefeller University
Stanford University
Stevens Institute of Technology
Temple University
Texas A&M University
Texas Tech University
University of Arizona
University of California at Berkeley
University of California at Davis
University of California at Los Angeles
University of California at San Diego
University of Central Florida
University of Colorado (Boulder and Denver)
University of Connecticut
University of Dayton
University of Denver
University of Illinois at Urbana/Champaign
University of Iowa
University of Kansas
University of Maryland at College Park
University of Michigan
University of Minnesota
University of Nebraska at Lincoln
University of North Dakota
University of Oklahoma
University of Pennsylvania
University of South Alabama
University of Texas at Austin
University of Washington
University of Wisconsin at Madison
Virginia Polytechnic Institute
Washington State University
Yale University

Medical Schools

Albert Einstein College of Medicine
Boston University Medical Campus
Duke University Medical Center
Johns Hopkins University School of Medicine
Mayo Medical School
Medical College of Ohio at Toledo
Northwestern University Medical School
Ohio State University College of Medicine
Temple University School of Medicine
University of California at Los Angeles School of Medicine
University of California at San Diego School of Medicine
University of California at San Francisco School of Medicine
University of Chicago Pritzker School of Medicine
University of Cincinnati College of Medicine
University of Colorado School of Medicine
University of Kansas Medical Center
University of Minnesota School of Medicine
University of Nebraska Medical Center
University of North Carolina School of Medicine
University of Pennsylvania School of Medicine
University of Texas Health Sciences Center at San Antonio
University of Texas Southwestern Medical Center at Dallas
University of Washington School of Medicine
Yale University School of Medicine

APPENDIX D

QUESTIONNAIRE FACSIMILE

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

OMB No. 3145-0067
Expiration Date 2/28/94

The Fourth National Science Foundation and National Institutes of Health

National Survey of Academic Research Instruments and Instrumentation Needs

1992 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 WILL NOT BE IDENTIFIED IN PUBLISHED SUMMARIES OF THE DATA.

It is estimated that the response to this survey will require an average of one hour. If you wish to comment on this burden, please contact Herman Fleming, Reports Clearance Officer, NSF, at (202) 357-9520 and the Office of Management and Budget, Paperwork Reduction Project (OMB 3145-0067), Washington, D.C. 20503.

Institution _____

Department/Facility _____

_____

This form should be returned to your survey coordinator. Your cooperation in returning the survey questionnaire promptly is very important.

For assistance with this questionnaire which cannot be provided by your survey coordinator, please contact Luz Tatum or Michele Holubek of Quantum Research Corporation at (301) 657-3070 or toll-free at (800) 369-0896.

Background and Instructions

Good policy-making requires sound information 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. This Congressionally-mandated survey is vital to help the National Science Foundation, National Institutes of Health, and other Federal agencies set equipment funding levels and priorities. This survey will update findings from previous studies and document current trends in: (a) the amount, cost, and condition of the scientific research equipment 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.

This questionnaire seeks a broad overview of equipment-related expenditures and needs in this department (or non-departmental research facility). Please keep the following in mind as you complete the survey:

(1) These questions should be answered by the department chairperson or facility director or by a knowledgable designee.

- Items 1-8 (Part A) are factual in nature and may be delegated to any person or persons who can provide the requested data. **In this section, informed estimates are acceptable whenever precise information is not available from annual reports or other data sources.**
- Items 9-17 (Part B) call for judgments about equipment-related research needs and priorities of the department (or facility) as a whole.

(2) These data are requested for your institution's 1992 Fiscal Year.

(3) **Please return this form to your institution's survey coordinator.** Do not mail the form to NSF or NIH.

Part A. Descriptive Information and Instrumentation-Related Expenditures

1. Does this department (or facility) have any scientific research equipment[1] (whether purchased or otherwise acquired) with an ORIGINAL COST of $20,000 or more? **(Circle One)**

Yes	1	**(CONTINUE** with Item 2)
No	2	**(SKIP** to Item 18)

2. This is: **(Circle One)**

An academic department	1	**(CONTINUE** with Item 3)
A nondepartmental research facility	2	**(SKIP** to Item 6)

CHECK BOX if response is an ESTIMATE

3. Number of doctoral degrees awarded from July 1991 through June 1992 to students in this department: **(Indicate Number)**

Number ..... _____ ☐

4. Number (headcount) of FULL-TIME faculty members[2] in this department:

Number ..... _____ ☐

5. Number (headcount) of FULL-TIME faculty members[2] in this department who are participating in on-going research projects:

Number ..... _____ ☐

6. Department (or facility) expenditures for purchase/acquisition of scientific research equipment[1] DURING THE INSTITUTION'S 1992 FISCAL YEAR:

FY 1992 expenditures for scientific research equipment[1] $ _____ ☐

[1] **"Scientific Research Equipment"** is any item (or interrelated collection of items comprising a system) of non-expendable tangible property or software, having a useful life of more than two years and a 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, the institution's own funds, industry, etc.

[2] **"Faculty member"** includes regular and visiting faculty and researchers of faculty-equivalent rank; does **NOT** include postdoctorates.

7. What were the sources of funds for the scientific research equipment purchased/acquired DURING THE 1992 FISCAL YEAR? **(Specify the approximate percentage contributed by each applicable source.)**

Funding Source	**Percent**
Federal Sources:	
a. NSF (National Science Foundation)	_____
b. NIH (National Institutes of Health)	_____
c. DOD (Department of Defense)	_____
d. DOE (Department of Energy)	_____
e. USDA (Department of Agriculture)	_____
f. Other Federal sources **(Please specify)**	_____
_____	_____
_____	_____
_____	_____
Non-Federal Sources:	
g. Institutional funds	_____
h. State and/or local government grant or appropriation	_____
i. Private, nonprofit foundation	_____
j. Industry	_____
k. Other **(Please specify)**	_____
_____	_____
_____	_____
Total:	100%

8. FY 1992 expenditures for maintenance/repair and operation of scientific research equipment in this department (or facility) **(Do not include fringe benefits or overhead costs. If personnel work in both maintenance/ repair and operation, pro-rate their salaries for each category.)**

		CHECK if an ESTIMATE
A. Maintenance/Repair Costs:		
(1) Service contracts or field service for maintenance and repair of individual instruments	$ _____	☐
(2) Salaries of institution (or department) provided maintenance/repair personnel (Pro-rate if personnel do not work full-time in this department/facility or on servicing of research equipment.)	$ _____	☐
(3) Other institution (or department) provided maintenance/repair, including costs of supplies, equipment, and facilities for servicing research instruments in this department/facility	$ _____	☐
B. Operating Costs		
(1) Salaries for technicians or other personnel paid to operate research equipment (Pro-rate if personnel do not work full-time in this department/facility or on operating research equipment.)	$ _____	☐
(2) Other operating costs (Specify types of costs included.) _____ _____ _____	$ _____	☐
C. Total		
Total maintenance/repair and operating costs for research equipment in this department/facility **(Total should be the sum of all costs recorded in A and B above.)**	$ _____	☐

Part B. Adequacy of and Need for Research Equipment

9. Are the instrumentation support services (e.g., machine shop, electronics shop) at this department (or facility): **(Circle One)**

Excellent	1
Adequate	2
Insufficient	3
Nonexistent, but needed	4
Nonexistent and not needed	5

10. 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: **(Circle One)**

Excellent	1
Adequate	2
Insufficient	3

11. Over the past three years, have the instrumentation needs of the research program in this department (or facility): **(Circle One)**

Increased (e.g., due to expanding staff or program or other factors)	1
Remained about the same	2
Declined	3

12. Over the past three years, has the amount of usuable research equipment in this department (or facility): **(Circle One)**

Increased substantially (50% or more in aggregate cost/value)	1
Increased	2
Remained about the same (±10% in aggregate cost/value)	3
Decreased	4
Decreased substantially (50% or more in aggregate cost/value)	5

13. Over the past three years, has the adequacy of the research equipment in this department (or facility): **(Circle One)**

Improved	1
Remained about the same	2
Declined	3

14. Has your research instrumentation funding support from the following sources generally increased, decreased, or remained about the same over the past three years? **(Circle One in Each Row)**

Use "Not Applicable" only if you received <u>NO</u> instrumentation funding in the past three years from the funding source.

	Source	Increased	Remained about the same	Decreased	Not applicable
a.	Federal government	1	2	3	4
b.	State/local equipment appropriations and equipment funded as part of state/local capital projects	1	2	3	4
c.	Internal institutional funds	1	2	3	4
d.	Private nonprofit foundations/ organizations	1	2	3	4
e.	Industry	1	2	3	4
f.	Other **(Please specify)** _____	1	2	3	4

15. If greater Federal funding of research equipment were possible, in which single area would increased investment be most beneficial to investigators in this department (or facility)? **(Circle One)**

Large systems costing over $1 million (supercomputers, large reactors, etc.) 1

Instrument systems in the $50,000 to $1 million range 2

Equipment in the $20,000-$50,000 range 3

General enhancement of equipment and supplies in labs of individual Principal Investigators (items generally below $20,000) 4

Other (Specify) 5

_____

_____

_____

16. What three items costing $20, 000 or more (including the cost of accessories) are the topmost priorities in this department (or facility)? **Please list in priority order beginning with priority No. 1.**

In addition to naming the instrument, please estimate its cost and indicate whether it is needed to: (1) replace an existing instrument; (2) expand capacity -- i.e., more copies of existing equipment; or (3) upgrade capabilities -- i.e., to perform experiments you cannot do now.

	Item Description	Approximate Cost Per Item	Reason Needed	
(1)	_____	$ _____	Replace existing instrument	1
	_____		Expand capacity	2
	_____		Upgrade capabilities	3
(2)	_____	$ _____	Replace existing instrument	1
	_____		Expand capacity	2
	_____		Upgrade capabilities	3
(3)	_____	$ _____	Replace existing instrument	1
	_____		Expand capacity	2
	_____		Upgrade capabilities	3

17. Are there any important subject areas (pharmacokinetics, genetic engineering, superconductivity, etc.) in which investigators in this department (or facility) are unable to perform critical experiments in their areas of research interest due to lack of needed equipment? **(Circle One)**

Yes	1	**(CONTINUE** with Item 17a)
No	2	**(SKIP** to Item 18)

17a. IF YES IN Q17: In what subject areas is improved instrumentation most needed? **(Specify up to three areas)**

1. _____

2. _____

3. _____

18. Thank you for completing this questionnaire. Please indicate the total amount of time required to complete this form.

Time required to complete this form: _____ Hours _____ Minutes

Please indicate the name, title, and telephone number(s) of the person(s) who provided the information in Part A and Part B. *PLEASE PRINT OR TYPE.*

Part A

Name: _____

Title: _____

Phone: ( ) _____ FAX: ( ) _____

Part B (If different from above)

Name: _____

Title: _____

Phone: ( ) _____ FAX: ( ) _____

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ARLINGTON, VA 22230

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ACADEMIC RESEARCH INSTRUMENTS AND INSTRUMENTATION NEEDS: 1992

NSF 94-321