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ABSTRACT

This report addresses concerns about the quality of biomedical and behavioral research conducted in the United States and the role that federally supported research and training plays in developing it. In addition, current and projected supply of and demand for scientists in the biomedical and behavioral fields is assessed. These fields include the clinical sciences, basic biomedical sciences, behavioral sciences, health services research, and nursing research. Research and training funding, involvement of Ph.D. scientists in clinical investigations, expansion of the postdoctoral population in basic medical sciences, and career outcomes of former National Institutes of Health predoctoral trainees and fellows are among the other areas assessed. In addition to specific recommendations related to each field, three general recommendations are presented: (1) the primary emphasis of National Research Service Awards programs should continue to be on postdoctoral rather than predoctoral training in most fields; (2) training grants should continue to be the dominant mechanism of support (the institutional component of such grants providing badly needed support to department programs); and (3) clinical investigators are still in short supply and efforts to attract them to research careers should continue. Supporting documentation and detailed data used in analysis leading to recommendations are included in appendices. (JM)

INSTITUTE OF MEDICINE

1983 REPORT

Personnel Needs and Training for Biomedical and Behavioral Research

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THE 1983 REPORT
of the

Committee on National Needs for
Biomedical and Behavioral Research Personnel

Institute of Medicine
National Academy of Sciences

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NOTICE: The project that is the subject of the report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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PREFACE

This is the seventh report of the Committee on National Needs for Biomedical and Behavioral Research Personnel pursuant to the request contained in the National Research Service Awards Act of 1974 (P.L. 93-348 as amended). In that Act, Congress requested the National Academy of Sciences to conduct a continuing study of the nation's overall need for biomedical and behavioral research personnel, the subject areas in which such personnel are needed, and the kinds and extent of training that should be provided by the federal agencies authorized to provide National Research Service Awards--the National Institutes of Health (NIH), the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA), and the Division of Nursing, Health Resources and Services Administration (HRSA). The National Center for Health Services Research (NCHSR) was also authorized to provide National Research Service Awards in the Health Services Research Act of 1978 (P.L. 95-623).

In the previous six reports issued since 1975, the Committee has concluded that the federal programs for training in these fields should be reoriented to provide less stimulus to Ph.D. production and more support to postdoctoral training, especially in the clinical and behavioral sciences. Accordingly, the Committee has recommended that the agencies change the allocation of their training grant and fellowship awards from predominantly predoctoral training to predominantly postdoctoral. The Committee recommended this be done by: (1) holding the number of postdoctoral trainees in the basic biomedical fields constant at about the level that prevailed in 1975 (3,200) while reducing the number of predoctoral trainees in the basic biomedical sciences to about 70 percent of the 1975 level; (2) reversing the allocation of awards in the behavioral sciences from the 1975 distribution which was 90 percent predoctoral, to one which is 30 percent predoctoral and 70 percent postdoctoral; (3) increasing the number of postdoctoral awards in the clinical sciences by about 10 percent over the 1975 level; (4) expanding the existing training programs in the category of health services research and bringing the authority for training by the National Center for Health Services Research under the NRSA Act; and (5) providing support for 300 trainees and fellows annually in the category of nursing research, with no more than 15 percent of these awards to be made at the postdoctoral level.

In this seventh report we have extended the data base through 1981-82 and made both short-term and long-term projections of supply and demand in these fields. The short-term projections help to assess demand in the academic sector through 1988 and therefore are most useful in determining the appropriate level of postdoctoral research training to be supplied by NRSA programs. The long-term projections extend into the 1990s when many graduate students in the mid-1980s will begin their careers as independent investigators. These projections therefore are more applicable to the determination of appropriate levels of predoctoral research training to be provided by NRSA programs.

Our recommendations in this report are directed to NRSA programs in FY 1985-87. Although we have made some adjustments to prior recommendations on the basis of our latest assessment of the supply/demand situation that is likely to prevail in the second half of the 1980s, we have not arrived at conclusions substantially different from those of past reports, e.g.:

- The primary emphasis of NRSA programs should continue to be on postdoctoral rather than predoctoral training in most of the biomedical fields.
- Training grants should continue to be the dominant mechanism of support--the institutional component of such grants provide badly needed support to departmental programs.
- Clinical investigators are still in short supply and efforts to attract them to research careers should be continued.

But medical school faculties are aging and unlikely to expand much during the next few years, and so a significant problem will soon become that of providing enough faculty positions to ensure an adequate flow of young clinical investigators into research careers. This is a problem that cannot be solved solely at the training level. It is more appropriately addressed by consideration of the level of research funds and other financial resources available to support faculty members and their research endeavors. If college enrollments decline as expected in the 1980s, compensating growth in the other sources of funds must occur in order to provide research opportunities for young scientists.

Robert L. Hill, Ph.D.
Chairman

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1. Introduction and Summary

We are concerned here about the quality of biomedical and behavioral research conducted in this country and the role that federally supported research training plays in developing and maintaining it. Evidence about the quality of research and the scientists who conduct it often becomes available only over a rather long period. Hence, we must be aware of the long-term effects of the training programs. We must also try to anticipate future research personnel needs in a quantitative sense. Thus a major part of this report is devoted to an assessment of the current and projected supply of and demand for scientists in the biomedical and behavioral fields.

Two fundamental principles underlie the work of this Committee over the past 8 years:

1. vigorous research activity is the key to continual progress in most scientific and technical fields and
2. an adequate flow of well-trained new scientists is necessary to maintain the quality and vitality of research conducted in these fields.

With these principles in mind, the Committee has attempted to respond to the task presented to the National Academy of Sciences (NAS) by Congress in the National Research Service Award (NRSA) Act of 1974 (P.L. 93-348) and amendments. The NAS was asked to determine the nation's need for biomedical and behavioral research personnel and to assess the research training programs offered through the National Institutes of Health (NIH), the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA), and the Division of Nursing of the Health Resources and Services Administration (HRSA).

In the previous six reports issued since 1975, the Committee has outlined its methodology, formulated conceptual models of how the market works in these fields, and developed analytical models that have proved useful in monitoring the system and making projections. In the process, we have compiled a substantial body of relevant data, most of which is presented in the Appendix.

The Committee has interpreted national needs primarily, but not exclusively, in terms of the number of positions expected to be available in both the academic and nonacademic sectors for doctorate-level biomedical and behavioral investigators. The number of positions available reflects the market demand for scientists and depends on an array of economic, political, and sociological factors, one of the most important of which is the availability of funds to support research. We have attempted to define the appropriate level of training to be supplied by the above-mentioned federal agencies on the basis of projections of supply and demand, considerations of how the system works to produce trained researchers and teachers, and by examination of employment patterns and practices.[1]

Although these short-term market projections have weighed heavily in our deliberations, we also have been influenced by a perception that training support contributes not only to the quantity of students entering a field, but also to the quality of the training environment and the competence of the program graduates. The immediate effect of training support for a field is to increase the number of students entering the field. In the longer term, the probable effect is to increase the quality of research.

We believe that much of the recent progress made in biomedical research in this country can be traced to the strong federal commitment to research and training that emanated from the National Cancer Act of 1937 and subsequent legislation. That commitment has been instrumental in establishing a powerful and effective biomedical research enterprise based on a cooperative arrangement between the federal government, acting principally through the NIH, and the universities. This enterprise is a national resource that has provided this country with a superb base for health related services and technological leadership in many biomedical and behavioral fields. Developments during the past 30 years have transformed our knowledge and understanding of biology. Achievements of research in many disciplines during this period have led to new technologies contributing to a flood of discoveries in molecular biology, biochemistry, physiology, and medicine.

Recombinant DNA technology, which makes possible the transfer of hereditary units from one species to another, represents a significant addition to the "new biology." It permits, for example, bacteria to become "factories" that produce substances of biological and medical importance. It has already led to the synthetic production of human insulin, somatostatin, and growth hormone. The effectiveness of these substances in treating insulin-dependent diabetes and certain types of dwarfism is now undergoing clinical trial. Techniques for combining genes can also yield large quantities of pure antigen which in the

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[1] For an extended discussion of the system by which biomedical and behavioral scientists are trained and absorbed into research positions, see Chapters 3 and 4 and also the 1981 Report of this Committee (NRC, 1975-81, pp. 10-15).

near future may be used to produce safer and more potent vaccines for immunization against specific infectious agents.

Substantial progress has been achieved in understanding of the immune system. Scientists have uncovered genetic mechanisms that control the immune response to such invaders as cancer cells, transplanted organs, and environmental agents that cause allergies. Involved here is the discovery of the major histocompatibility complex (MHC). A region of this "super gene" appears to be the major regulator of the immune response to foreign substances or antigens. Disorders such as multiple sclerosis, juvenile diabetes mellitus, systemic lupus erythematosus, and myasthenia gravis may be associated with certain recognition antigens on the surface of cells--antigens located under the directions of MHC. Further knowledge of MHC can result in more effective means for supplementing natural resistance to these diseases, as well as better techniques for organ and tissue transplantation.

Highly specific antibodies can now be produced in the laboratory through a procedure that consists of fusing in culture a myeloma cell with single lymphocytes from an immunized animal. The resulting hybridoma yields clones of lymphocytes that emit monoclonal antibodies which have the potential for development of specific vaccines, diagnostic tests, and treatments for many diseases. Recently, for example, investigators have used human lung cancer cells to immunize animals and then prepare monoclonal antibodies which can distinguish human tumor cells from normal cells. This technology makes possible the detection of cancer at a very early stage. Eventually, clinicians may be able to attach radioactive or chemotherapeutic agents to the antibodies and thereby kill cancer cells without harming surrounding healthy tissue.

The detection and isolation of oncogenes has provided a new paradigm for cancer research. Oncogenes are dominant genetic elements whose expression within a normal cell leads to malignant transformation. Some major questions remain to be answered. At what point in the processes leading to malignancy do oncogenes act? What are the functions of these oncogenes and by what mechanisms do they effect cell transformation? Knowledge of the metabolic pathways in which genes and their products interact could ultimately lead to the development of rational strategies for the treatment and prevention of malignant cells.

The developments described above may be viewed as dividends on past federal investment in biomedical research and training. But it is critically important to recognize that the federal commitment to support biomedical research and training means that federal budget decisions have great impact on these activities, although other sources of funds are available to some extent.

The rationale for government support of biomedical and behavioral research "derives from its responsibility for the general welfare to do that which is necessary whenever other mechanisms do not suffice" (NRC, 1975-81, 1979 Report, p. 19). Research training is a necessary and vital adjunct to the research program. The Committee's recommendations for research training have been formulated to promote

stability in the market for biomedical and behavioral research personnel, while preserving the quality of the training program and ensuring that adequate numbers of well-trained scientists are available to meet the nation's needs.

PRIORITY FIELDS

One of the most difficult components of the Committee's task has been that of determining the appropriate allocation of training grant and fellowship funds among fields. For purposes of this study, the biomedical and behavioral fields have been divided into five major categories as shown in the following table along with the distribution of National Research Service Awards made in the last 6 years and the Committee's recommended distribution through 1987:

Distribution of National Research Service Awards

Categories	Actual 1977-82	Recommended 1982-87[a]
1) Biomedical Sciences	56%	57%
2) Behavioral Sciences	10%	9%
3) Clinical Sciences	32%	30%
4) Health Services Research	1%	2%
5) Nursing Research	1%	2%
	100%	100%

[a]Awards in the short-term (3-month) training program for health profession students have been calculated at 1/4 of a full-time equivalent award. An average of 1,600 such awards per year from 1982-87 (400/yr. on an FTE basis) have been included in the clinical sciences in this table.

Although the boundaries between these categories are not always clearly drawn in practice,[2] conceptually they define fairly distinct sets of problems. Each major category has been analyzed separately, and our recommendations have generally been directed to the allocation of training awards among these major categories.

It has proven to be an especially difficult task to identify priority fields within each major category. The Committee has in the past identified certain fields such as biostatistics, biomathematics, epidemiology, toxicology, environmental health, and the clinical sciences as meriting high priority for training support. However, we

[2] See Appendix Table D5 for the taxonomy used to define the categories.

have refrained from being more specific because basic research is such a fluid and unpredictable activity. We have found no way of accurately predicting precisely where and when the important scientific developments will occur and we have no recent data to indicate that some or all of the earlier conclusions are still valid. The Committee's position is that the peer review system continues to provide the best available method for distributing training funds within the general guidelines we recommend. Those guidelines are based on the informed judgment of the panelists and Committee members, who have considerable experience relevant to the task and who have reviewed extensive analyses of the current and projected market for scientists in each area and other relevant information.

SUMMARY OF CURRENT OUTLOOK

In previous reports the Committee has called attention to the sustained growth in the number of biomedical Ph.D.s occupying postdoctoral positions. Although a period of postdoctoral training has long been a traditional and accepted phase in a bioscientist's career, the build-up of the postdoctoral pool was viewed as an indication that the supply of biomedical scientists was growing faster than the number of positions requiring their skills. Indeed, more than 40 percent of the biomedical postdoctoral trainees who received their doctorate degree between 1971 and 1975 reported that they remained in postdoctoral status longer than they might otherwise have done because they could not secure a more permanent position (NRC, 1975-81, 1977 Report, Vol 2, p. 31).

There now are some indications that the postdoctoral pool of bioscientists may soon level off. Most important, the number of bioscience graduate students has begun to drop, and this is likely to result in fewer Ph.D.s produced and fewer of them entering the postdoctoral pool. There has been very little growth in biomedical Ph.D. production since 1972.

The Committee has expressed concern about the lack of interest in research careers on the part of young physicians. The sustained expansion of clinical faculties in medical schools since the early 1960s has contributed to the demand for clinical investigators, and the growing number of unfilled positions is evidence of need. In 1981, the Association of American Medical Colleges (AAMC) reported to the Committee that only about 21 percent of individuals newly hired to fill vacancies on clinical faculties at medical schools were physicians with some postdoctoral research training (NRC, 1975-81, 1981 Report, p. 2). There is an increasing tendency to rely on practice income generated by medical school faculty members to bolster medical school and departmental budgets. This growing dependence tends to detract from faculty members' commitments to clinical investigation. To the extent that faculty members must help support their salaries and expenses through clinical practice, the research effort is weakened.

Problems in our health care system are increasing while funds for health services research and training are being sharply reduced. There is likely to be additional pressure on federal agencies to stress mission-oriented research and cost containment over other issues of long range importance in the system.

The number of nurses with doctoral degrees in biomedical and behavioral fields is increasing but only about 7 percent of these individuals reported research as a major activity in 1980. There is as yet no solid core of qualified investigators in the area of nursing research.

In the behavioral sciences, the clinical fields are flourishing as opportunities for careers as counselors and therapists have become more attractive. Coverage of these services by health insurance plans has spread in recent years. But most behavioral science research is performed by nonclinical behavioral scientists, and enrollments as well as Ph.D. production in the nonclinical fields are declining.

Only a few years ago most observers were projecting that Ph.D. production would continue to increase until the early 1980s (Cartter, 1976; NSF, 1975). The flattening out of the Ph.D. production curves since the the early 1970's is a rather surprising event, one that promises to produce more short-term balance in the market for Ph.D.s than was earlier thought possible.

However, the demographic patterns that are emerging present another set of problems. Perhaps the most serious is that biomedical, clinical, and behavioral science faculties at colleges and universities are not likely to expand at all for the rest of this decade. This means fewer opportunities for research careers for young scientists in these fields. Persons born during the baby boom that occurred roughly between 1946 and 1965 are now largely past the prime college age years, so enrollments in higher education are expected to decline steadily for the next 10 or 12 years. Faculty size is determined partly by enrollments and partly by the availability of R and D funds. In the biomedical fields, we expect the latter to grow at modest real rates of about 2 percent annually for the next few years. But this probably will not be enough to offset the drop in revenues resulting from declining enrollments. Hence, faculties will not grow and academic vacancies will occur mainly by attrition. Consequently, young researchers will find it difficult in these circumstances to begin their careers as independent investigators. Without adequate numbers of young investigators, who typically are highly innovative and creative, where will the new ideas for advances in basic research come from? Should progress in research be tied so closely to demographic cycles? What policies can be invoked now that would tend to mitigate the imbalances between supply and demand caused by the cyclical demographic and social changes? How can this country's competitive advantage in technological areas such as the new biotechnology be maintained?

In our view, these problems are most likely to be solved by greater expenditure of funds to support research. However, this Committee has been asked to determine the nation's need for biomedical and behavioral research personnel, and we have interpreted that task as one of estimating the number of positions that are likely to be available under realistic conditions. A market-based approach such as

this is only one of several possible approaches that could be taken to estimate national personnel needs. One alternative approach would base personnel needs on a projected level of research expenditures somehow tied to total health care costs. But this approach also has problems, e.g., what will health care costs be in 5 years and what is an appropriate ratio of research expenditures to health care costs? No matter what criterion is used, there is always a danger that some unforeseen development will negate the assumptions on which projections are made and will lead to market imbalances--either shortages or surpluses--and a misallocation of resources. There is no known protection against that event. The training recommendations described below have been formulated on the basis of our best judgment as to what the demand for these scientists is most likely to be, given the demographic trends, the most likely future levels of research funds, and the financial conditions of our colleges and universities.

RECOMMENDATIONS

We direct the following recommendations concerning the level and distribution of National Research Service Awards to fiscal years 1985-87. The analyses, background, and discussion leading to these recommendations may be found in succeeding chapters of this report.

Clinical Sciences

1. The number of postdoctoral research training positions in the clinical sciences should be about 2,600 per year from 1985 through 1987, and the number of physicians receiving research training should be increased from the current level of less than 2,000 to about 2,200, or 85 percent of these postdoctoral positions.

2. The training grant is the most appropriate mechanism for post-doctoral training of physicians, most of whom have no prior research experience. At least 85 percent of the clinical science training positions should be on training grants, the remainder on fellowships.

3. One of the most effective mechanisms for training physician-scientists is the Medical Scientist Training Program (MSTP) administered by the National Institute of General Medical Sciences (NIGMS). The costs of MSTP as a share of total NIGMS funds for predoctoral training have been increasing steadily. To ensure an appropriate balance, we therefore recommend that MSTP's share over the near future not exceed 25 percent of NIGMS predoctoral training funds with a target goal of approximately 725 trainees. We believe this can be accomplished without loss in quality by introducing administrative changes, such as the recently adopted limitation on length of MSTP support for an individual trainee (6 years). Other modifications now under consideration by the agency have a potential for increasing output per MSTP dollar.

4. We endorse the program of institutional grants that provides up to 3 months research training for health professions students without incurring the payback provision, and recommend that it be continued. If possible, the stipends should be raised to a level which is competitive with other opportunities of these students for summer earnings.

Basic Biomedical Sciences

1. Predoctoral training in these fields should be supported at a level of about 4,250 trainees per year.

2. Postdoctoral training in the basic biomedical sciences should continue to support about 3,200 fellows per year.

Behavioral Sciences

1. In view of the rapidly developing movement away from the research fields and into the more clinical fields of the behavioral sciences, the Committee recommends that research training support not be further eroded. The number of predoctoral awards in the behavioral sciences should be maintained at the 1981 level--about 650 per year.

2. The development of postdoctoral training programs should be encouraged by gradually increasing the number of postdoctoral research training awards from the 1981 level of about 350 to 540 by 1987.

3. About 80 percent of the behavioral science awards should be traineeships and 20 percent should be fellowships.

Health Services Research

1. We recommend that 330 trainees and fellows be supported annually in the catgory of health services research.

2. Earlier efforts by the Committee and others to develop adequate data on health services research personnel and training should be supplemented by further investigations. The Institute of Medicine should convene a meeting of interested parties to review the status of university-related centers for health services research and to outline a plan for collecting additional data on potential demand for investigators in this field.

Nursing Research

1. The number of training awards in nursing research should be about 300 per year.

2. A maximum of 15 percent of these awards should be at the post-doctoral level.

TRAINING DATA

To give perspective to the resources devoted to training by the NIH, ADAMHA, and HRSA, we present below the training budgets as a percentage of research expenditures by these agencies over the past 10 years. Training expenditures declined from almost 18 percent of research expenditures in 1971 to 7 percent in 1981. This results from a steady 4 percent per year increase in research expenditures and a 5 percent per year decrease in training expenditures over this period after adjusting for inflation.

Training Expenditures as a
Percent of Research Expenditures

1971	17.7%
1972	15.1%
1973	10.4%
1974	12.9%
1975	10.5%
1976	7.7%
1977	7.4%
1978	7.4%
1979	6.4%
1980	7.3%
1981	7.0%

SOURCE: See Appendix Table D4.

Nevertheless, the current number of trainees is in fact quite close to that recommended by this Committee. The point is that large adjustments in training programs have been occurring right along--correctly, we think--in view of the ample number of biomedical and behavioral Ph.D.s being produced annually and serving in postdoctoral positions. A transition has been made from a period of high training levels to one of modest levels. What is needed now is not a huge infusion of funds for training but rather a reasonably stable program geared to preserving the long-term quality of research. By definition, there will always be a shortage of the best people, and it is in the sense of ensuring the availability of some minimum number of very good people for careers in biomedical and behavioral research that NRSA programs are most useful.

NATIONAL RESEARCH SERVICE AWARDS FOR 1981 AND 1982

In 1981 NIH/ADAMHA/HRSA made 13,325 awards under the NRSA program--a slight increase over the 13,191 made in 1980. In 1982 the number of

awards dropped to 12,907. The awards were distributed among the fields as follows:

	1981	1982
Biomedical Sciences:	52.4%	55.6%
Behavioral Sciences:	8.0%	7.5%
Clinical Sciences:[a]	38.5%	35.8%
Nursing Research:	1.1%	1.1%
	100.0%	100.0%

[a] Awards in the short-term training program for health professions students were counted as 1/4 of a full-time equivalent award.

These distributions reflect an increased emphasis on the clinical fields and away from the biomedical sciences and health services research, compared to recent years. This shift occurred in part because ADAMHA revised its classification of research training awards in 1981. This change resulted in 114 additional awards in the clinical sciences, up from none in 1980, and the elimination of any awards in health services research.

Another reason for the increase in clinical sciences is that awards in the short-term (3 months) training program for health professions students increased from 911 in 1980 to 1,275 in 1981 and 1,339 in 1982.

Despite the apparent increase in training awards in the clinical sciences category, the number of physicians and other health professionals participating in the research training program was less than 2,000 out of the nearly 2,800 clinical science postdoctoral awards made by the NIH in 1981.[3] The remaining awards went to Ph.D.s.

The following tables show the 1981 and 1982 research training awards made by the NIH, ADAMHA, and HRSA under the NRSA program, and the Committee's recommendations for 1985-87. Cost estimates for the recommended programs are also provided.

Training grant awards are defined as the number of predoctoral or postdoctoral training positions to be made available on the grant. The number of awards is generally quite close, but not exactly equal to the number of individuals trained, since some training grant awards may provide support to more than one trainee during the year.

[3] Special tabulation prepared by the Statistics and Analysis Branch, Division of Research Grants, NIH. October 7, 1982.

TABLE 1.1 Aggregated Numbers of NIH/ADAMHA/HRSA Traineeship and Fellowship Awards for FY 1981 and FY 1982[a]

		TOTAL ALL FIELDS	Biomedical Sciences	Behavioral Sciences	Clinical Sciences	Nursing Research
FY 1981	TOTAL	13,325	6,482	988	5,723	132
	Predoctoral	7,264	3,708	639	2,791	126
	Postdoctoral	6,061	2,774	349	2,932	6
	Trainees	11,430	5,047	861	5,506	16
	Predoctoral	7,043	3,656	588	2,787	12
	Postdoctoral	4,387	1,391	273	2,719	4
	Fellows	1,895	1,435	127	217	116
	Predoctoral	221	52	51	4	114
	Postdoctoral	1,674	1,383	76	213	2
FY 1982	TOTAL	12,907	6,608	896	5,270	133
	Predoctoral	6,989	3,673	516	2,669	131
	Postdoctoral	5,918	2,935	380	2,601	2
	Trainees	11,097	5,202	781	5,101	13
	Predoctoral	6,784	3,620	484	2,667	13
	Postdoctoral	4,313	1,582	297	2,434	0
	Fellows	1,810	1,406	115	169	120
	Predoctoral	205	53	32	2	118
	Postdoctoral	1,605	1,353	83	167	2

[a]These are total numbers of awards for traineeships and fellowships. Data on the number of new starts for FY 1981 and FY 1982 are not available. See Tables 1.2 and 1.3.

SOURCES: Office of the Administrator, ADAMHA (5/25/82 and 6/6/83); Division of Nursing, HRSA (4/9/81 and 10/1/82); Division of Research Grants, NIH (9/22/82 and 7/12/83).

TABLE 1.2 NIH Traineeship and Fellowship Awards for FY 1981 and FY 1982[a]

			Biomedical Sciences						Clinical Sciences				
		TOTAL ALL FIELDS	Total Biomedical Sciences	Basic Biomedical Sciences	Math, Physics, Engineering, Other	Community and Environmental Health	Epidemiology and Biostatistics	Behavioral Sciences	Total Clinical Sciences	Medical Scientist Program	Other Clinical Sciences	Short-Term Trainees	Nursing Research[b]
FY 1981	TOTAL	11,902	5,963	5,574	104	51	234	198	5,609	705	3,629	1,275	132
	Predoctoral	6,456	3,473	3,268	17	27	161	115	2,742	705	861	1,176	126
	Postdoctoral	5,446	2,490	2,306	87	24	73	83	2,867	0	2,768	99	6
	Trainees	10,212	4,624	4,320	28	51	225	164	5,408	705	3,428	1,275	16
	Predoctoral	6,322	3,453	3,249	16	27	161	115	2,742	705	861	1,176	12
	Postdoctoral	3,890	1,171	1,071	12	24	64	49	2,666	0	2,567	99	4
	Fellows	1,690	1,339	1,254	76	0	9	34	201	0	201	0	116
	Predoctoral	134	20	19	1	0	0	0	0	0	0	0	114
	Postdoctoral	1,556	1,319	1,235	75	0	9	34	201	0	201	0	2
FY 1982	TOTAL	11,661	6,122	5,785	89	32	216	248	5,158	676	3,143	1,339	133
	Predoctoral	6,337	3,461	3,285	21	17	138	128	2,617	676	678	1,263	131
	Postdoctoral	5,324	2,661	2,500	68	15	78	120	2,541	0	2,465	76	2
	Trainees	10,002	4,793	4,525	25	31	212	197	4,999	676	2,984	1,339	13
	Predoctoral	6,195	3,437	3,265	18	16	138	128	2,617	676	678	1,263	13
	Postdoctoral	3,807	1,356	1,260	7	15	74	69	2,382	0	2,306	76	0
	Fellows	1,659	1,329	1,260	64	1	4	51	159	0	159	0	120
	Predoctoral	142	24	20	3	1	0	0	0	0	0	0	118
	Postdoctoral	1,517	1,305	1,240	61	0	4	51	159	0	159	0	2

[a]These are total numbers of awards for traineeships and fellowships. Data on the number of new starts for FY 1981 and FY 1982 are not available.

[b]Most of the awards in Nursing Research are from the Division of Nursing, HRSA. Figures for FY 1981 also include 8 predoctoral trainee awards and 1 predoctoral fellowship award from the NIH. Figures for FY 1982 includes 13 predoctoral trainee awards from the NIH.

SOURCE: Division of Nursing, HRSA (4/9/81 and 10/1/82); Division of Research Grants, NIH (9/22/82 and 7/12/83).

TABLE 1.3 ADAMHA Traineeship and Fellowship Awards for FY 1981 and FY 1982[a]

		TOTAL ALL FIELDS	Biomedical Sciences			Behavioral Sciences	Clinical Sciences[b]
			Total Biomedical Sciences	Biological Sciences	Epidemiology and Biostatistics		
FY 1981	TOTAL	1,423	519	398	121	790	114
	Predoctoral	808	235	158	77	524	49
	Postdoctoral	615	284	240	44	266	65
	Trainees	1,218	423	308	115	697	98
	Predoctoral	721	203	127	76	473	45
	Postdoctoral	497	220	181	39	224	53
	Fellows	205	96	90	6	93	16
	Predoctoral	87	32	31	1	51	4
	Postdoctoral	118	64	59	5	42	12
FY 1982	TOTAL	1,246	486	365	121	648	112
	Predoctoral	652	212	139	73	388	52
	Postdoctoral	594	274	226	48	260	60
	Trainees	1,095	409	292	117	584	102
	Predoctoral	589	183	110	73	356	50
	Postdoctoral	506	226	182	44	228	52
	Fellows	151	77	73	4	64	10
	Predoctoral	63	29	29	0	32	2
	Postdoctoral	88	48	44	4	32	8

[a]These are total numbers of awards for traineeships and fellowships. Data on the number of new starts for FY 1981 and FY 1982 are not available.
[b]Effective FY 1981, ADAMHA has been using a different system for classifying their trainees and fellows. In prior years, ADAMHA reported training in Health Services Research but none in Clinical Sciences.

SOURCE: Office of the Administrator, ADAMHA (5/25/82 and 6/6/83).

TABLE 1.4 Committee Recommendations for NIH/ADAMHA/HRSA Predoctoral and Postdoctoral Traineeship and Fellowship Awards for FY 1985-87[a]

Fiscal Year	Type of Program		TOTAL ALL FIELDS	Basic Biomedical Sciences[b]	Behavioral Sciences[c]	Clinical Sciences: Medical Scientist Program	Clinical Sciences: Other Clinical Science Programs	Health Services Research	Nursing Research
1985	TOTAL	Total	12,495	7,450	1,090	725	2,600	330	300
		Predoc.	6,070	4,250	650	725	d	190	255
		Postdoc.	6,425	3,200	440	0	2,600	140	45
	Trainees	Total	8,475	4,250	895	725	2,230	250	125
		Predoc.	5,755	4,250	535	725	d	140	105
		Postdoc.	2,720	0	360	0	2,230	110	20
	Fellows	Total	4,020	3,200	195	0	370	80	175
		Predoc.	315	0	115	0	0	50	150
		Postdoc.	3,705	3,200	80	0	370	30	25
1986	TOTAL	Total	12,545	7,450	1,140	725	2,600	330	300
		Predoc.	6,070	4,250	650	725	d	190	255
		Postdoc.	6,475	3,200	490	0	2,600	140	45
	Trainees	Total	8,515	4,250	935	725	2,230	250	125
		Predoc.	5,755	4,250	535	725	d	140	105
		Postdoc.	2,760	0	400	0	2,230	110	20
	Fellows	Total	4,030	3,200	205	0	370	80	175
		Predoc.	315	0	115	0	0	50	150
		Postdoc.	3,715	3,200	90	0	370	30	25
1987	TOTAL	Total	12,595	7,450	1,190	725	2,600	330	300
		Predoc.	6,070	4,250	650	725	d	190	255
		Postdoc.	6,525	3,200	540	0	2,600	140	45
	Trainees	Total	8,560	4,250	980	725	2,230	250	125
		Predoc.	5,755	4,250	535	725	d	140	105
		Postdoc.	2,805	0	445	0	2,230	110	20
	Fellows	Total	4,035	3,200	210	0	370	80	175
		Predoc.	315	0	115	0	0	50	150
		Postdoc.	3,720	3,200	95	0	370	30	25

[a]These are total numbers of recommended awards. See Table 1.1 for number of actual awards made in FY 1981 and FY 1982. The number of new starts in any given year is sensitive to fluctuations in the funding level and thus oscillates more rapidly than does the total number of awardees.

[b]Recommendations for biostatistics, epidemiology, community and environmental health, and other training fields not specifically shown in this table are included here.

[c]The allocation of awards in the behavioral science fields between traineeships and fellowships is based on the distribution that prevailed in FY 1976, i.e., 82% traineeships, 18% fellowships.

[d]A program of short-term research training (3 months) for health professions students during summer and off-quarters was authorized in 1978. The Committee has endorsed this program in principle but makes no recommendations for the number of students to be supported under it. The 1978 amendments to the NRSA Act authorized expenditures for this program of up to 4% of appropriated training funds. In FY 1982 1,339 trainees were awarded stipends.

TABLE 1.5 Estimated Cost of Recommended NIH/ADAMHA/HRSA Training Programs for FY 1985-87 (millions of dollars)[a]

Fiscal Year	Type of Program	TOTAL ALL FIELDS	Biomedical Sciences	Behavioral Sciences	Clinical Sciences: Total	Clinical Sciences: MSTP	Clinical Sciences: Short-Term Training[b]	Clinical Sciences: Other	Health Services Research	Nursing Research
1985	TOTAL	202.7	107.5	18.2	68.0	10.8	2.1	55.1	5.1	3.9
	Trainees	131.1	49.6	15.2	60.6	10.8	2.1	47.7	4.0	1.7
	Fellows	71.6	57.9	3.0	7.4	–	–	7.4	1.0	2.2
	Predoc.	*77.1*	*49.6*	*9.4*	*12.9*	*10.8*	*2.1*	–	*2.2*	*3.0*
	Postdoc.	*125.6*	*57.9*	*8.8*	*55.1*	–	–	*55.1*	*2.9*	*0.9*
1986	TOTAL	205.9	108.5	20.0	68.4	11.1	2.1	55.2	5.1	3.9
	Trainees	134.0	50.6	16.7	61.0	11.1	2.1	47.8	4.0	1.7
	Fellows	71.9	57.9	3.3	7.4	–	–	7.4	1.1	2.2
	Predoc.	*78.6*	*50.6*	*9.6*	*13.2*	*11.1*	*2.1*	–	*2.2*	*3.0*
	Postdoc.	*127.3*	*57.9*	*10.4*	*55.2*	–	–	*55.2*	*2.9*	*0.9*
1987	TOTAL	209.4	109.5	21.9	68.8	11.4	2.1	55.3	5.2	4.0
	Trainees	137.0	51.6	18.3	61.4	11.4	2.1	47.9	4.0	1.7
	Fellows	72.4	57.9	3.6	7.4	–	–	7.4	1.2	2.3
	Predoc.	*80.4*	*51.6*	*9.9*	*13.5*	*11.4*	*2.1*	–	*2.3*	*3.1*
	Postdoc.	*129.0*	*57.9*	*12.0*	*55.3*	–	–	*55.3*	*2.9*	*0.9*

[a]Calculations were based on 1982 average cost figures derived from NIH data and assumed the following: 1) a 5% increase in stipends for FY 1983, held constant for later years; 2) a 5% per year increase in tuition; and 3) a reduction in institutional costs to a maximum per year of $1,500 for predoctoral trainees and fellows, $2,500 for postdoctoral trainees, and $3,000 for postdoctoral fellows. The stipend increase and the reduction in institutional allowances are regulations that became effective in FY 1983.
[b]Estimate assumes 1,200 trainees.

ESTIMATED TRAINING COSTS PER AWARD IN FY 1982 (dollars)

FY 1982	Predoctoral: Biomed. Sci.	Predoctoral: Behavioral Sci.	Predoctoral: Clinical Sciences: MSTP	Predoctoral: Clinical Sciences: Short-Term Training	Predoctoral: Health Services Research	Predoctoral: Nursing Research	Postdoctoral: Biomed. Sci.	Postdoctoral: Behavioral Sci.	Postdoctoral: Clinical Sci.	Postdoctoral: Health Services Research	Postdoctoral: Nursing Research
Trainees	11,613	13,602	13,776	1,699	11,613	11,613	20,596	21,953	20,987	20,596	20,596
Fellows	11,613	13,602	–	–	11,613	11,613	17,321	18,535	19,263	17,321	17,321

ADDENDUM

It has been the Committee's practice following the publication of its reports to hold a meeting at which interested persons can present their reactions and comments to the Committee. The last report was issued in 1981 and a public meeting was held in 1982. A number of significant points were made which we feel deserve mention and further consideration. The meeting is summarized below.

PUBLIC MEETING, JUNE 2, 1982

Following the publication of the Committee's 1981 Report, a public meeting was held on June 2, 1982, to receive comments from the scientific community. Twelve speakers representing a variety of organizations made brief statements about different aspects of the report to the Committee and an audience of about 100 persons. The list of speakers in order of appearance and their affiliations are as follows:

Gerald D. Shockman	American Society for Microbiology
James Ferguson Jr.	University of Pennsylvania School of Medicine
Frank G. Standaert	Georgetown University
Robert W. Krauss	Federation of American Societies for Experimental Biology
Thomas Kennedy	Association of American Medical Colleges
James M. Jones	Minority Fellowship Program Director
Ora Strickland	American Nurses' Association
Michael S. Pallak	American Psychological Association
Mortimer Appley	Clark University
Edward J. Callahan	West Virginia University Medical Center
Martha Pitel	American Association of Colleges of Nursing
Mitzi Duxbury	University of Minnesota School of Nursing

Copies of prepared remarks from several of the speakers are available upon request to the Committee. Some of the major points made by the speakers at the meeting are summarized below:

1. The Committee may have overlooked a growing demand for certain types of bioscientists outside the academic sector, especially in the new biotechnology industry. The Committee's estimate of about 1,000 positions per year opening up for biomedical Ph.D.s in industry is probably too conservative.
2. The role of the M.D. in basic research should be examined and encouraged. Medical students are often insulated from basic research and researcher role models.

3. Data from the placement service of the Federation of American Societies for Experimental Biology (FASEB) show a stable number of job applicants and employers. There is no evidence in these data that an oversupply of bioscientists exists.
4. Identifying physician scientists and enumerating them remains a critical problem because of the absence of any certification process. An accurate assessment of supply or demand cannot be made without an accurate count of physician scientists.
5. At least 85 percent of funds for training minority students should be used at the predoctoral level.
6. The Committee is urged to reconsider its recommendation for training in the behavioral sciences that drastically shifts the emphasis to postdoctoral training. Although it is recognized that the need for postdoctoral training is growing in some behavioral subfields, the magnitude of the recommended shift is unrealistic. The decline in predoctoral support by the agencies has been devastating. There is no objection to increasing research training at the postdoctoral level, but it should not be at the expense of predoctoral training support.
7. The Committee should extend its horizons beyond the short-term analysis it has traditionally employed. A longer-term view is necessary because scientists needed in the 1990s are already in training. We need to know what the situation will be in the 1990s when many people trained in the 1960s will be retiring.
8. Nursing research includes many more areas than health services research and should not be combined with it in the report. The Committee's support for Nursing Research Emphasis Grants is to be commended. Although progress has been made in providing training in the area of nursing research, we still lack a substantial nucleus of nurse researchers as principal investigators engaged in nursing research programs.

The Committee acknowledges these comments and appreciates the constructive manner in which they were presented. The suggestions have been given careful consideration in our deliberations and those of the Panels. While perhaps not all of them are reflected in this report to everyone's satisfaction, the comments are highly valued by our members as representing important points of view on these difficult issues.

2. Clinical Sciences

As of 1982, the market opportunities for clinical investigators continued to be favorable, with medical school faculties still growing and providing places for young scientists interested in research careers. The immediate problem remains one of recruiting physicians to undertake research training. In the longer term our projections indicate that the situation is likely to undergo appreciable change. With the possibility of a physician surplus developing, the number of medical schools will stop increasing, enrollments will stabilize or decline, and faculty growth will be slower, thereby reducing the number of positions available for new entrants into the clinical investigator pool. At the same time, greater financial uncertainty in medical schools is likely to aggravate the long-standing difficulty of attracting and retaining high-quality clinical investigators. The problem appears to be related more to the difficulty of obtaining funds for research than to the availability of training positions. Despite reduced employment opportunities, however, shortages of clinical investigators are likely to persist for the next few years.

INTRODUCTION AND OVERVIEW

Clinical investigation, as defined by the Committee, includes research on patients, on samples derived from patients as part of a study on the causes, mechanisms, diagnosis, treatment, prevention, and control of disease, or on animal studies by scientists identifiable as clinical investigators on the basis of their other work. Clinical investigation is generally performed in academic health centers. In that environment collaboration with basic scientists is facilitated, appropriate resources for human studies are available, and multidisciplinary teams are at hand to provide skills needed for comparative assessment of old and new methods. Accordingly, the Committee's assessment of demand for clinical investigators is focused on the

medical school sector. The latest data on medical school enrollment, as well as faculty professional fee income, and clinical R and D expenditures[1] in constant 1972 dollars, suggest that this market continued through 1982 to exhibit a relatively strong demand for clinical investigators (Table 2.1). Highlights of the new data presented in Table 2.1 are as follows:

- demand for faculty in clinical departments continued to be strong
- clinical R and D expenditures rebounded sharply in 1980 after a decline in 1979, but have fallen back since then
- professional fee income continues to be one of the fastest growing revenue items in medical schools, and now far exceeds the level of clinical R and D expenditures
- the number of physicians applying for NIH research grants has increased in the last 5 years, but the number of grants awarded on behalf of M.D. principal investigators has not changed appreciably.

A point of particular interest in the most recent (1982) data is the finding that the number of full-time faculty[2] in clinical

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[1] Clinical R and D expenditures are estimated by applying a correction factor to total R and D expenditures reported by the Association of American Medical Colleges. The correction factor for any year is the proportion of total NIH obligations that goes to support clinical research, using NIH's Central Scientific Classification System as the basis for characterizing individual research grants. Financial data are given in constant 1972 dollars unless noted otherwise.

[2] Faculty in this report means academically employed, regardless of tenure status or rank. In a medical school, full-time faculty refers to faculty whose salary is paid either in full or in part by the medical school or its affiliated institutions and hospitals. Included are faculty on both strict and geographic full-time. Strict full-time medical school faculty are those who receive their entire professional income as a fixed annual amount from funds controlled by the medical school or its parent institution, who devote their full time to programs of the medical school, and whose professional activities are under the direct auspices and control of the medical school.

Geographic full-time medical school faculty are those who receive a guaranteed base salary, all or most of which is paid from funds controlled by the medical school, but who may earn income from professional activities, who conduct all of their professional activities in the institution paying the base salary, and whose professional activities are under the direct auspices and control of the medical school.

BLE 2.1 Current Trends in Supply/Demand Indicators in the Clinical Sciences

	Fiscal Year								Annual Growth Rate from 1975 to Latest Year	Latest Annual Change	Average Annual Change from 1975 to Latest Year
	1975	1976	1977	1978	1979	1980	1981	1982			
UPPLY INDICATORS (New Entrants):											
. Professional doctorates participating in NIH training grants and fellowships[a]	2,884	1,970[b]	1,927	1,981	2,005	2,172	1,961	n/a	-6.2%	-9.7%	-154
. M.D. degrees awarded	12,716	13,634	13,614	14,391	14,966	15,135	15,673	15,985	3.3%	2.0%	467
DEMAND INDICATORS:											
. Expenditures for clinical R and D in medical schools (1972 $, mil.)	$241	$232	$268	$282	$273	$297	$290	$295	2.9%	1.7%	$7.7
. Professional service income in medical schools (1972 $, mil.)	$240	$306	$391	$406	$441	$496	$530	$611	14.3%	15.3%	$53.0
. Total clinical R and D and professional service funds (1972 $, mil.)	$481	$538	$659	$688	$714	$793	$820	$906	9.5%	10.5%	$60.7
. Budgeted vacancies in medical schools:											
(1) Clinical departments	1,632	1,782	1,865	2,000	2,100	2,279	2,231	2,264	4.8%	1.5%	90
(2) Basic science departments	618	664	638	697	721	776	656	668	1.1%	1.8%	7
. Clinical faculty/student ratio[c]	0.302	0.306	0.311	0.322	0.323	0.334	0.331	0.341	1.8%	3.0%	0.006
ABOR FORCE:											
. M.D.s primarily engaged in research[d]	7,944	8,514	9,786	11,437	14,515	15,377	n/a	n/a	14.1%	5.9%	1,487
. Full-time faculty in clinical departments	26,846	28,603	30,349	32,622	34,057	36,665	37,716	40,148	5.9%	6.4%	1,900
. NIH research grants awarded to M.D.s:											
(1) Number of competing grants	1,466	1,276	1,276	1,511	1,648	1,465	1,350	1,281	-1.9%	-5.1%	-26
(2) % of total competing grants	29%	30%	30%	27%	27%	28%	25%	25%	-2.1%	0.0%	-0.6%
. M.D. applicants for NIH research grants:											
(1) Number of competing applicants	2,751	2,796	3,122	3,260	3,238	3,292	3,166	n/a	2.4%	-3.8%	69
(2) % of total competing applicants	29%	29%	29%	28%	26%	28%	25%	n/a	-2.4%	-10.7%	-0.7%
. M.D. success rate (awards/applicants)	0.53	0.46	0.41	0.46	0.50	0.45	0.43	n/a	-3.4%	-4.4%	-0.017
ENROLLMENTS:											
a. Medical students	54,076	56,244	58,266	60,424	62,582	64,020	65,412	66,484	3.0%	1.6%	1,773
b. Residents and clinical fellows	41,197	43,908	44,795	46,444	50,188	52,491	52,871	57,504	4.9%	8.8%	2,330
c. Total	95,273	100,152	103,061	106,868	112,770	116,511	118,283	123,988	3.8%	4.8%	4,102

cludes Fogarty International Center programs.
oes not include Transition Quarter.
tio of full-time clinical faculty to a 4-year weighted average of total enrollments of medical students, residents, and clinical fellows (WS), where $(WS)_t = 1/6(S_t + 2S_{t-1} + \ldots_{t-2} + S_{t-3})$.
ere is some question about the interpretation of these data. For a discussion, see later section of this chapter.

URCES: AAMC (1972-83, special tabulations of 4/8/82, 5/17/82, and 6/15/83); AMA (1960-82, 1963-81); NIH (1966-82); NRC (1979-83, Query #5).

departments has grown somewhat faster than expected over the past 3 years, apparently financed by higher than anticipated levels of both faculty fee income and clinical R and D expenditures. Full-time clinical faculty was up 17.9 percent in 1982 from the 1979 level--an average growth rate of better than 5 percent per year. There are indications, however, that the market outlook for the next 5 years may be changing, as described below. Slower growth in the medical education complex can be anticipated.

Professional Fee Income in Medical Schools

During the early 1960s, professional fee income generated by faculty members grew steadily at more than 10 percent per year in real terms. But starting in 1968, a dramatic upswing occurred. These funds grew at an annual rate of more than 25 percent, and overtook funds for clinical research as a source of revenue for medical schools. The latest data show a 15 percent real increase in 1982 over 1981. Although fee income in most schools is the only part of the departmental budget that has been increasing, the prospect for clinical faculties to generate additional revenue seems clouded. The impact of cost containment devices, such as the diagnosis-related group (DRG) Medicare prospective payment plan, as well as increased competition between teaching hospitals and community physicians, make it unlikely that this source of institutional revenue will continue to grow at its previous rates.

Clinical R and D Expenditures

Approximately half of total medical school revenues were derived from research funding in the late 1960s. By contrast, such funds now amount to one-fifth of total revenues. Clinical R and D currently accounts for about 38 percent of total biomedical R and D expenditures (Appendix Table A7). In constant dollar terms, estimated clinical R and D expenditures dropped $7 million in 1981 and rose only $5 million in FY 1982. Its real growth rate over the past 7 years has averaged about 3 percent per year. The Committee foresees a somewhat slower growth rate through 1988.

Enrollments

After more than 30 years of expansion, the nation's medical schools are showing some decline in applications and enrollments. The total of medical students, residents, and clinical fellows has grown at an average annual rate of only 3.2 percent since 1979. Hit simultaneously by steep borrowing rates and substantial tuition increases, student indebtedness continues to grow. Perhaps because of rising costs, as well as possibly changing perceptions of alternative career options, the number of medical school applicants for the

1981-82 academic year was 16 percent below that of 1972-73, and the entering class of 1982-83 numbered about 100 fewer students than in the preceding year (Korcok, 1983). Based on survey responses from all medical schools, the expectation is for net decreases in first-year enrollment of 47 and 85 in 1983-84 and 1984-85, respectively (AAMC, 1983). Moreover, the possibility of a physician surplus seems to rule out an expansion of medical education in the foreseeable future. Some growth in the number of residents may occur, however, despite evidence of recent reductions in available positions because of cost constraints. This may result from incentives for expansion of graduate medical training contained in the Medicare prospective payment plan recently passed by Congress.[3] Also, with the growing complexity of medical services, prolongation of training programs and increase in number of residency years are a possibility.

MAINTAINING THE FLOW OF NEW CLINICAL INVESTIGATORS

The future vitality of clinical investigation depends upon the medical schools' ability to maintain a flow of qualified physician investigators. One measure of the flow is the number of new M.D. principal investigators on NIH research grants. Although the number of newly hired physicians in medical schools has more than doubled since 1965, the number of new M.D. principal investigators has remained at roughly 400 (Bryll, 1983). The proportion of physicians among all first-time principal investigators has gone down from 29.3 percent in 1977 to 24.2 percent in 1980. The number of physicians and other professional doctorates participating in NIH research training programs has declined on average by more than 6 percent per year since 1975 (Table 2.1, line 1a).

A no-growth situation in medical schools could have serious implications for the future demand for physician investigators. Inasmuch as NIH-supported principal investigators are in large part members of medical school faculties, the future demand is linked closely to the hiring of new faculty which, in turn, is dependent on net increase in faculty size and number needed to replace losses due to attrition. Our projections have shown that a cessation of growth in size of faculty would reduce faculty hiring by more than half (NRC, 1975-81). New M.D. principal investigators have in recent years constituted only 10-15 percent of the number of "new hires"--a finding consistent with the fact that only 20-25 percent of physician "new

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[3] In addition to a medical education pass-through, Congress also doubled the current adjustment for indirect teaching costs. With the new adjustment, teaching hospitals will receive additional payment of 12-13 percent for each 0.1 increase in the residents-to-beds ratio.

hires" have had postdoctoral research training.[4] Because medical schools include the vast majority of physicians holding academic appointments, a decline in hiring of new faculty will affect the demand for new M.D. investigators far more than other new researchers. Further, the increasing dependence of medical schools on practice income is likely to favor the recruitment of clinically-oriented physicians over physician investigators for the limited number of faculty openings.

MONITORING THE CLINICAL INVESTIGATOR POOL

The Committee has for several years been tracking the number of physicians reporting research as a primary activity to the American Medical Association (AMA). These data have been used as an indicator of shifts in interest in research careers on the part of physicians. A consistent annual decrease since 1968 has been followed since 1975 by a steady increase. The latest available data show almost a 6 percent rise in 1980 over 1979 (Table 2.1). This pattern does not conform to data compiled by the Committee on the number of physicians participating in NIH research training programs, nor is it compatible with other indications of physicians' research activities available from the Association of American Medical Colleges. Efforts are underway to identify the causes of the discrepancy.

The need to know much more about the population of clinical investigators has prompted the Committee to consider the establishment of a system by which such information could be readily obtained. As a first step, a roster could be established that would include physicians, dentists, veterinarians, and other health professionals with interest or training in research. The data files on NIH/ADAMHA trainees and fellows and principal investigators maintained by the Committee could be combined with the AAMC's Medical School Faculty Roster, the Dental School Faculty Roster, and files maintained by various professional societies to form a composite data base that would include almost all clinical investigators. Samples could be drawn from the population for use in periodic surveys of research activity, sources of support, training background, and other information vital to the task of monitoring this important pool of scientists. The cooperation of the AMA, AAMC and other professional organizations would be required in developing this project.

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[4] The percentage of all new-hired M.D.s with postdoctoral research training fell from 28 percent in 1970 to a low of 20 percent in 1979, with a subsequent rise to 25 percent in 1981 (Sherman and Bowden, 1982).

SHORT-TERM RESEARCH TRAINING

The Committee in its 1979 report welcomed NIH's resumption of support for short-term research training as an important step in helping to revitalize interest in the pursuit of clinical investigation careers. Data from a Committee-sponsored study suggest that if the necessary number of clinical investigators is to be maintained, undergraduate medical students should be provided the time and opportunity to acquire firsthand knowledge of the excitement of working in a research laboratory (AAMC, 1981b). This is consistent with the findings of another study that indicates that research career decisions had largely been made during undergraduate medical school years (Davis and Kelley, 1982).

Starting in 1979 with 5 grantee institutions and 16 trainees, the current program has increased to 60 institutions and 1,026 trainees in FY 1982. As authorized in the 1978 amendments to the NRSA Act, students could pursue training for periods up to 3 months during summer and off-quarters without incurring a payback obligation. Training supported by these institutional awards is not restricted to a single discipline or department. The potential for this type of training has been enhanced by two developments since the Committee's last report. Under the most recent amendments to the NRSA Act, the payback obligation is now applicable only to awards in excess of 12 months, thereby increasing a program director's flexibility in planning trainee's research experience. Also, waivers may now permit the payment of short-term stipends within the regular (T-32) training grants.

The Committee believes that specific recommendations on the administration and size of this program should await the results of an evaluation. Accordingly, a two-pronged study is planned to determine the fraction of trainees who maintain their interests in research and who follow career pathways that include research activity. One approach entails an examination of records of trainees from the pre-NRSA era. In this connection, it is to be noted that NIH training grants provided support for periods of 1-3 months to 12,645 individuals during the years 1960-1974. Subsequent postdoctoral training, NIH/ADAMHA grant activity, academic appointments, and publications will be scrutinized. The other approach will compare the research plans of NRSA short-term trainees with those of their non-trainee classmates and graduates of the non-grantee institutions. This area of the study will also involve analysis of responses to the AAMC annual survey of graduating seniors.

MEDICAL SCIENTIST TRAINING PROGRAM

The Medical Scientist Training Program (MSTP) supports combined medical and scientific training leading to both the M.D. and Ph.D. degrees. Sponsored by the National Institute of General Medical

Sciences (NIGMS), the program has grown from 3 grantee institutions and 17 trainees in FY 1964 to 23 institutions and about 700 trainees currently. Based on an outcome study of the first 53 graduates of MSTP with respect to research retention, rate of advance in academic positions, research grant success, and publication performance, the program has been successful (NRC, 1975-81, 1981 Report).

Reflecting our enthusiasm for the program we have previously recommended that high priority be given to protecting MSTP training slots, should it become necessary for budget reasons to reduce the overall number of NRSA trainees. That recommendation has been implemented, even though the support of all research training has generally been under severe restraint. Moreover, trainee slots have been maintained at a time when total expenditures per "graduate" have become significantly higher on MSTP grants than on other predoctoral training grants, reflecting both a larger annual per trainee cost and a longer period of stipend support for MSTP participants.

In its 1979 report, the Committee called for a moratorium on further expansion, pending the development of more analytic information regarding the program. A study during the past year by NIGMS staff indicates that the relative cost of MSTP has been rising steadily over the last few years. Expressed as a percent of total NIGMS funds for predoctoral training, the MSTP share has increased from 16 percent in FY 1977 to 25-28 percent currently. Continuation of this trend could place in jeopardy the support of regular predoctoral programs, which, it should be emphasized, are essential to the continuing vitality of MSTP. The need to curb this growth in costs has therefore become a matter of great concern.

A reasonable means for ensuring an appropriate balance would be to retain for MSTP over the near future a share of NIGMS predoctoral training funds that does not exceed 25 percent. The Committee believes that the suggested stabilization of relative cost can be achieved without detriment to quality through introducing various modifications in program administration. One such measure, limiting the period of MSTP support for an individual trainee to a total of 6 years and authorizing discontinuity in support, became effective July 1, 1983. A direct effect of that change will be to encourage greater flexibility on the part of institutions in the operation of their MSTP grants. It should be feasible, for example, for program directors to include within the training sequence periods of support from non-MSTP sources, such as research grants and institutional remission of tuition. In the Committee's view, these changes have the potential of enhancing program output, i.e., to increase the number of graduates per MSTP dollar by means of "freeing up" some trainee slots.

Reference was made earlier to a limited 1981 study sponsored by the Committee regarding the quality of MSTP output. As the program enters its third decade of operation, the Committee believes the time is appropriate to undertake a study of broader scope. It would be useful, for example, to obtain a comprehensive picture of costs, training completion rates, post-training employment histories, scientific accomplishment, etc.

INVOLVEMENT OF PH.D. SCIENTISTS IN CLINICAL INVESTIGATION

Implicit in the Committee's numerical recommendations for postdoctoral training in the clinical sciences has been the recognition that individuals with other than health professional doctorates engage in clinical investigation. Indeed, early evidence of an appreciable involvement of non-health professionals in clinical investigation emerged from the Committee's 1976 survey of recent Ph.D. recipients in biomedical and behavioral fields (NRC, 1975b). Approximately 31 percent of the respondents in that survey described themselves as engaged in research that directly involved human subjects (or animals in the case of veterinary science research) or samples derived therefrom, as part of a clinically-oriented study. That such involvement had been expanding became apparent from the Committee's analysis of staffing patterns in NIH-funded clinical projects over the 1973-78 period.[5] As can be seen from Figure 2.1, Ph.D.s were the

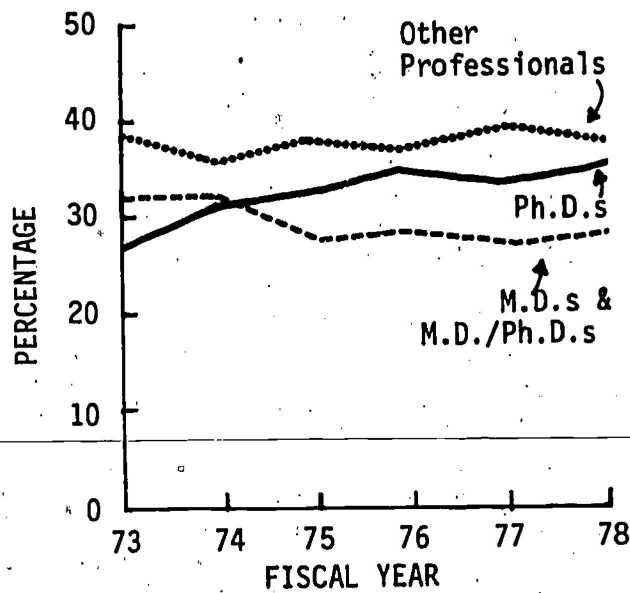

FIGURE 2.1 Participation of Ph.D., M.D., and other scientists on clinical research grants sponsored by NIH, 1973-78. Data are shown as percentage of total paid full-time equivalent employment on the grants. See Appendix Table A15.

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[5] An Annual NIH Survey, Manpower Report, collected data from principal investigators regarding persons receiving salary from each grant during those years. The NIH Central Scientific Classification System was used in this analysis to identify clinical grants--i.e., those involving human subjects as individuals or as groups.

only degree category of personnel to exhibit a relative increase in full-time equivalent employment on those clinical research grants, rising from 27 percent in 1973 to almost 35 percent in 1978.

In earlier reports, the Committee has commented on the declining attractiveness of clinical investigation as a career option for the young physician. It is to be noted in this connection that the proportion of NIH postdoctoral research traineeship and fellowship positions filled by M.D.s in 1981 was about one-half that in 1973 (Table 2.2). During that period the number of Ph.D. bioscience researchers increased substantially, with a net growth of 450 per year in the pool of postdoctoral appointees in the academic sector (see Chapter 3, Table 3.1). As will be noted below, a growing number of Ph.D. scientists has moved into clinical departments of medical schools (Appendix Table A12). Under these circumstances, one of the questions examined by the Committee concerned the extent to which the steady increase in the postdoctoral training pool might be used to mitigate a possible shortage of physician investigators. In this section of the report, the Committee addresses that question.

Ph.D. Faculty Members with Appointments in Clinical Departments of Medical Schools

The clinical departments of medical schools provide a useful starting point for examining the role that Ph.D. scientists play in clinical research. Not only is the preponderance of clinical investigation in the United States performed at that site, but it is also possible to chart in some detail the growing frequency of Ph.D.s with faculty appointments in clinical departments. For example, full-time faculty in clinical departments of U.S. medical schools, including pathology departments, trebled between 1967-68 and 1981-82. Compared to other degree types, only the Ph.D.s exhibited an increase in share of the total. As a proportionate share of clinical department faculty, Ph.D.s rose from 11.5 percent in 1968 to 15.1 percent in 1982 (Appendix Table A12). The M.D., M.D./Ph.D., and "other" groups all declined slightly in percentage terms during this period.

The distribution of Ph.D. faculty in the clinical departments is uneven. The top four departments in number of Ph.D.s--psychiatry, internal medicine, pathology, and family practice--accounted for 61 percent of the total in 1981-82 (Appendix Table A13). As a fraction of the faculty of each clinical department, Ph.D.s ranged from about 5 percent in anesthesiology to over 31 percent in otolaryngology and in psychiatry.

Do Ph.D. faculty members in clinical departments differ from their counterparts in basic science departments in medical schools? In terms of the same selected characteristics, how do they differ from their physician colleagues? Relevant to these questions, three groups

of medical school faculty members will be compared in the following paragraphs:

1. Ph.D.s with primary appointments in clinical departments
2. Ph.D.s with primary appointments in basic science departments
3. M.D.s with primary appointments in clinical departments.

TABLE 2.2 Distribution of NIH Postdoctoral Trainees and Fellows, by Degree Type, 1971-81[a]

Fiscal Year		Total	M.D.s[b]	Ph.D.s[b]
1971	#	7,540	4,634	2,906
	%	100.0	61.5	38.5
1972	#	7,407	4,474	2,933
	%	100.0	60.4	39.6
1973	#	5,478	3,620	1,858
	%	100.0	66.1	33.9
1974	#	6,364	3,551	2,813
	%	100.0	55.8	44.2
1975	#	5,971	2,884	3,087
	%	100.0	48.3	51.7
1976	#	4,910	1,970	2,940
	%	100.0	40.1	59.9
1977	#	5,325	1,927	3,398
	%	100.0	36.2	63.8
1978	#	5,758	1,984	3,774
	%	100.0	34.5	65.5
1979	#	5,814	2,005	3,809
	%	100.0	34.5	65.5
1980	#	5,831	2,172	3,659
	%	100.0	37.2	62.8
1981	#	5,265	1,961	3,304
	%	100.0	37.2	62.8

[a]These data represent individuals who actually served in NIH-supported traineeship or fellowship positions. Thus, these counts may differ slightly from those shown in Chapter 1 which represent awards, not individuals on duty. Includes Fogarty International Center programs.

[b]"M.D." and "Ph.D." also include equivalent doctorate degrees. Persons with both M.D. and Ph.D. degrees are shown under "M.D."

SOURCE: NIH (special tabulation, 10/7/82).

The Faculty Roster maintained by the Association of American Medical Colleges permits a comparison of the three groups in relation to such characteristics as career age, academic rank, postdoctoral fellowship training, tenure status, extent of research participation, and research grant activity (Tables 2.3 and 2.4).

For purposes of the comparison, clinical departments were divided into five departmental categories: medical, surgical, hospital-based, psychiatry, and other clinical.[6] Except for psychiatry, inter-category differences were minor. In departments of psychiatry, Ph.D.s were considerably more numerous, constituting almost one-fourth of the 5,857 Ph.D.s in clinical departments in 1981-82. Extent of research participation sharply differentiated psychiatry department faculty members--both Ph.D. and M.D.--from those of all other clinical departments. The percentage of Ph.D. faculty in psychiatry reporting no research participation was almost triple that for all other clinical department Ph.D.s. The percentages of M.D. faculty reporting no research participation were 48 percent and 36 percent for psychiatry departments, and for all other clinical departments, respectively. For these reasons, data for faculty in psychiatry departments are shown separately from other clinical departments in Tables 2.3 and 2.4.

Clinical department Ph.D.s are younger in career age than both basic science department Ph.D.s and M.D. faculty in clinical departments. Consistent with younger career age, Ph.D.s in clinical departments generally hold lower academic rank than faculty in the other two groups. Ph.D. faculty in clinical departments are less likely to have taken a postdoctoral appointment than Ph.D.s in basic science departments, but more likely to have had such training than M.D.s in clinical departments. Ph.D.s in clinical departments are found much less frequently in tenured or tenure-track status than those in basic science departments. Compared with clinical department M.D.s, however, there is very little difference in this regard. Clinical department Ph.D.s are more likely to have no research involvement than is true for Ph.D.s in basic science departments. The extent of their participation in research, however, is considerably greater than for M.D. faculty in clinical departments, particularly with respect to the percentage for whom research is the primary professional responsibility. Finally, clinical department Ph.D.s stand midway between the other two groups in relation to research grant activity, with basic science Ph.D.s substantially higher than clinical department M.D.s in their application, approval, and award rates for NIH/ADAMHA grants.

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[6] Data applicable to the individual departmental categories can be found in Appendix Tables A16 and A17.

TABLE 2.3 Statistical Profile of Full-Time Ph.D. Faculty in Medical School Departments, 1982

		Department									
		Basic Sci.		Clinical[a]		Psychiatry		Other		Total	
		N	%	N	%	N	%	N	%	N	%
CAREER AGE (Yrs. since Ph.D.)	less than 5	744	10.9	842	18.7	275	20.2	130	14.6	1,991	14.6
	6-10	1,242	18.1	1,025	22.8	286	21.0	173	19.5	2,726	20.1
	11 or more	4,864	71.0	2,626	58.4	803	58.9	586	65.9	8,879	65.3
	TOTAL	6,850	100.0	4,493	100.0	1,364	100.0	889	100.0	13,596	100.0
ACADEMIC RANK	Professor	2,328	34.0	786	17.5	323	23.7	133	15.0	3,570	26.3
	Assoc. Prof.	2,168	31.7	1,292	28.8	328	24.1	149	16.8	3,937	29.0
	Asst. Prof.	1,995	29.1	1,986	44.2	566	41.5	170	19.1	4,717	34.7
	Instructor	224	3.3	325	7.2	132	9.7	18	2.0	699	5.1
	Other & Unk.	135	1.9	104	2.3	15	1.1	419	47.1	673	4.9
	TOTAL	6,850	100.0	4,493	100.0	1,364	100.0	889	100.0	13,596	100.0
YEARS OF POSTDOCTORAL RESEARCH TRAINING	None	3,160	47.8	2,581	63.4	1,081	81.7	637	71.4	7,459	57.8
	1-2	2,116	32.0	934	22.9	175	13.2	175	19.6	3,400	26.4
	3-4	976	14.8	390	9.6	41	3.1	57	6.4	1,464	11.4
	5 or more	354	5.4	165	4.1	26	2.0	23	2.6	568	4.4
(1981 faculty)	TOTAL	6,606	100.0	4,070	100.0	1,323	100.0	892	100.0	12,891	100.0
TENURE STATUS	Tenured	3,431	50.1	1,171	26.1	411	30.1	421	47.4	5,434	40.0
	Tenure Track	1,473	21.5	1,045	23.3	240	17.6	148	16.6	2,906	21.4
	No Tenure	863	12.6	1,422	31.6	444	32.6	149	16.8	2,878	21.2
	Other & Unk.	1,083	15.8	855	19.0	269	19.7	171	19.2	403	17.4
	TOTAL	6,850	100.0	4,493	100.0	1,364	100.0	889	100.0	13,596	100.0
RESEARCH PARTICIPATION	None	321	4.7	438	9.7	358	26.2	217	24.4	1,334	9.8
	Some	5,381	78.6	2,755	61.3	757	55.5	521	58.6	9,414	69.3
	Primary	1,003	14.6	1,060	23.6	184	13.5	94	10.6	2,341	17.2
	Other & Unk.	145	2.1	240	5.3	65	4.8	57	6.4	507	3.7
	TOTAL	6,850	100.0	4,493	100.0	1,364	100.0	889	100.0	13,596	100.0
NIH/ADAMHA RESEARCH GRANT ACTIVITY[b] (Competing applications only)			Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)
	Applications[c]	3,979	58.1	1,835	40.8	270	19.8	151	17.0	6,235	45.9
	Awards[d]	1,241	31.2	455	24.8	78	28.9	22	14.6	1,796	28.8
	Approvals[e]	3,497	87.9	1,527	83.2	182	67.4	112	74.2	5,318	85.3

[a] Excludes departments of psychiatry. Ph.D.s in psychiatry departments appear to have different characteristics from those in other clinical departments. See Appendix Table A16 for more details.
[b] For these data, Basic Science includes pathology departments.
[c] Application rate = # applications/# faculty members.
[d] Award rate = # awards/# applications.
[e] Approval rate = # approved applications/# applications.

SOURCES: AAMC (1966-83, special tabulation prepared by George Bowden, NIH, 6/9/83); NRC (1979-83, special tabulation, 6/11/83).

TABLE 2.4 Statistical Profile of Full-Time M.D. Faculty in Medical School Departments, 1982[a]

		Department									
		Basic Sci.		Clinical[b]		Psychiatry		Other		Total	
		N	%	N	%	N	%	N	%	N	%
CAREER AGE (Yrs. since M.D.)	less than 5	6	0.9	1,133	4.4	81	3.4	10	2.6	1,230	4.2
	6-10	33	5.2	4,154	16.0	371	15.4	10	2.6	4,568	15.4
	11 or more	595	93.9	20,662	79.6	1,965	81.3	369	94.9	23,591	80.3
	TOTAL	634	100.0	25,949	100.0	2,417	100.0	389	100.0	29,389	100.0
ACADEMIC RANK	Professor	424	66.9	7,490	28.9	618	25.6	84	21.6	8,616	29.3
	Assoc. Prof.	122	19.2	6,334	24.4	569	23.5	29	7.5	7,054	24.0
	Asst. Prof.	71	11.2	9,704	37.4	1,016	42.0	22	5.7	10,813	36.8
	Instructor	11	1.7	2,250	8.7	203	8.4	0	0.0	2,464	8.4
	Other & Unk.	6	0.9	171	0.7	11	0.5	254	65.3	442	1.5
	TOTAL	634	100.0	25,949	100.0	2,417	100.0	389	100.0	29,389	100.0
YEARS OF POSTDOCTORAL RESEARCH TRAINING (1981 faculty)	None	295	43.8	17,685	72.6	2,108	87.5	283	73.3	20,371	73.2
	1-2	189	28.1	4,454	18.3	198	8.2	72	18.7	4,913	17.7
	3-4	115	17.1	1,555	6.4	51	2.1	19	4.9	1,740	6.2
	5 or more	74	11.0	649	2.7	51	2.1	12	3.1	786	2.8
	TOTAL	673	100.0	24,343	100.0	2,408	100.0	386	100.0	27,810	100.0
TENURE STATUS	Tenured	405	63.9	7,917	30.5	665	27.5	211	54.2	9,918	31.3
	Tenure Track	57	9.0	5,800	22.4	526	21.8	30	7.7	6,413	21.8
	No Tenure	55	8.7	7,078	27.3	763	31.6	61	15.7	7,957	27.1
	Other & Unk.	117	18.4	5,154	19.9	463	19.2	87	22.4	5,821	19.9
	TOTAL	634	100.0	25,949	100.0	2,417	100.0	389	100.0	29,389	100.0
RESEARCH PARTICIPATION	None	60	9.5	9,274	35.7	1,158	47.9	228	58.6	10,720	36.5
	Some	482	76.0	14,356	55.3	1,092	45.2	142	36.5	16,072	54.7
	Primary	73	11.5	1,083	4.2	76	3.1	5	1.3	1,237	4.2
	Other & Unk.	19	3.0	1,236	4.8	91	3.8	14	3.6	1,360	4.6
	TOTAL	634	100.0	25,949	100.0	2,417	100.0	389	100.0	29,389	100.0
NIH/ADAMHA RESEARCH GRANT ACTIVITY[c] (Competing applications only)			Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)
	Applications[d]	741	116.9	2,962	11.4	222	9.2	39	10.0	3,964	13.5
	Awards[e]	256	34.5	901	30.4	64	28.8	13	33.3	1,234	31.1
	Approvals[f]	660	89.1	2,434	82.1	119	53.6	36	92.3	3,249	82.0

[a]Excludes M.D.s who also hold a Ph.D. degree.
[b]Excludes departments of psychiatry. Faculty members in psychiatry departments appear to have different characteristics from those in other clinical departments. See Appendix Table A1-7 for more details.
[c]For these data, Basic Science includes pathology departments.
[d]Application rate = # applications/# faculty members.
[e]Award rate = # awards/# applications.
[f]Approval rate = # approved applications/# applications.

SOURCES: AAMC (1966-83, special tabulation prepared by George Bowden, NIH, 7/20/83); NRC (1979-83, special tabulation, 7/29/83).

Role of Ph.D.s in Clinical Investigation

The Ph.D. scientist in a clinical department generally engages in clinical investigation as an independent researcher, as a co-investigator, or as a provider of specialized skills involved with complex laboratory instrumentation and technologies. As independent investigators, Ph.D. epidemiologists have been largely responsible for the rapid pace of advancement in this discipline, particularly in the development of methodologic and analytic strategies. A 1979 symposium report provides examples of the Ph.D.'s role as a catalyst in initiating collaborative research within the clinical setting (Gillis, 1979). The report cites a collaborative study of pulmonary clearance of vasoactive hormones in patients that was a direct outgrowth of the basic scientist collaborator's earlier animal work. This role is also demonstrated in phase I drug studies. Here the Ph.D. pharmacologist is uniquely suited to gather information on how a drug introduced for the first time in man is absorbed, metabolized, and eliminated. Functioning as a source of laboratory expertise, the Ph.D. scientist often provides access to research tools that the clinically trained investigator might otherwise be less likely to exploit. Opportunity for the application of monoclonal antibodies, spectroscopic analysis of metabolic function, and molecular genetics to clinical problems are but a few examples. It is relevant in this connection that the National Council of the American Federation of Clinical Research decided in the past year to include faculty openings in Clinical Research's "Positions Available Listing" for Ph.D. scientists in departments of medicine and pediatrics (Zusman, 1983).

Clinical investigation takes many forms, ranging from a study of isolated tissue components to large-scale drug trials involving thousands of subjects and the pooled effort of many investigators in multiple sites. In that connection, two questions arise. How can these diverse forms of research be categorized? How is research effort--projects and dollars--distributed in terms of those categories? Answers to those questions would indicate, for example, whether the trend was now to use the human subject primarily as a source of materials or whether participation of the intact human continued to be essential to the research. A recently formulated taxonomy by Landau, as described by Bever (1980), is useful for this purpose. It consists of six major categories and numerous subgroupings within each category. The first two categories, for example, include: 1) research in which the subjects or their environments are manipulated experimentally, and 2) research on the management of a disease through available diagnostic and therapeutic modalities.

Legal, ethical, and regulatory constraints require that a physician play the primary investigative role for projects in those two categories. The remaining four categories of clinical investigation involve materials derived from humans; animal studies or models for human experimentation; epidemiologic studies; and miscellaneous projects (communications, data systems, etc.). For research in those categories, a Ph.D. frequently, or even predominantly, can serve as the principal investigator.

The distribution of NIH awards for clinical investigation in these categories is pertinent to the present discussion. Lipsett (1981) found that 1979 NIH grant-supported projects falling into Landau's first two categories represented the overwhelming majority of "human" projects supported by most Institutes. The funds involved tended to parallel the number of projects. It was his conclusion, therefore, that a physician must take the lead role in most of the NIH-sponsored research on human subjects. This conclusion is reinforced by the findings of an earlier study on NIAMDD grants for human-related studies over a 9-year period (Bever, 1980). For projects falling in Landau's first two categories, Bever determined that the principal investigators were almost exclusively M.D.s or persons with both the M.D. and Ph.D. degrees.

The Ph.D. scientist's role in clinical research has been enhanced not only by the increasing complexity and sophistication of biomedical technology and instrumentation, but also by a changing emphasis in clinical investigation. Analysis of research abstracts associated with the annual Atlantic City "Spring Meetings" of the American Federation for Clinical Research, the American Society for Clinical Investigation, and the Association of American Physicians for various years from 1953 through 1969 is informative (Feinstein and Koss, 1967, 1970, Feinstein et al, 1967). The analysis revealed that the proportion of "clinical" topics--as evidenced by papers that were either patient-centered, disease-oriented, or concerned with human material--had progressively declined, concomitant with a steady increase in the proportion of "basic" investigations, the materials for which were neither human nor diseased. More recently, Fishman and Jolly (1981) used the table of contents of one issue of the Journal of Clinical Research to demonstrate that research in clinical departments frequently "falls within the traditional purview of basic science departments." In keeping with the trend toward integration of the clinical and basic sciences, the NIH has announced a new program--the Physician Scientist Award--designed to promote opportunities for young clinicians to develop research skills and experience in a fundamental science.

The Committee has repeatedly stressed the importance of the physician-scientist in clinical investigation. This emphasis derives from the M.D.s irreplaceable role in bringing clinical insights to bear in the laboratory and in translating basic observations into clinical practice.

At the same time, factors such as the fall off in number of physicians seeking research training, increasing clinical activity on the part of medical school faculty, and the growing complexity of biomedical technology have opened new opportunities for the basic scientist in clinical investigation. A growing movement of young Ph.D. scientists into clinical departments of medical schools--for teaching, service, and especially for research activities--has occurred over the past 10-15 years. Indeed, research is now the primary functional activity for almost one-fourth of Ph.D. faculty in clinical departments. Of that group, some serve as independent investigators, conducting research on tissues and other substances of

human origin, developing biophysical and biochemical tests, pursuing animal studies, etc. Most function as collaborators in interdisciplinary investigations. Moreover, the participation of Ph.D. scientists helps to ensure the application of state-of-the-art technology to clinical studies. Barring unforeseen change, the Committee expects that for reasons cited earlier, this increasing involvement in clinical investigation by non-medically trained scientists will continue for the near term and will contribute to the advancement of clinical science.

THE MARKET OUTLOOK

A substantial part of the growth in medical school enrollment since 1960 has been due to the growth in number of schools, in addition to the expansion of class size. But with the demise of capitation grants, the pressure for class expansion will lessen. Therefore, any future enrollment growth for the next few years will likely be determined largely by the number of new schools to be formed, and there will probably not be many.

Almost all of the new schools formed since 1961 have been public schools (see Figure 2.2). In 1962 there were 44 public and 42 private schools. In 1981 these had increased to 75 public and 51 private schools--average annual growth rates of 2.8 percent and 0.8 percent, respectively. Therefore we would expect the public schools to have more faculty, students, funding, etc. And that is what we observe except in the case of faculty. Whereas the number of students in public medical schools began to increase faster than private school students in the mid-1960s (Figure 2.3), the number of clinical faculty in both cases has remained quite close (Figure 2.4). Private schools thus have much higher faculty/student (F/S) ratios than do public schools (Figure 2.5). These higher ratios are apparently financed by higher levels of R and D funding and professional fee income in private schools (Figure 2.6). Public medical schools tend in general to focus more on teaching than research activities.

The Demand Model for Clinical Faculty

The above results are entirely consistent with the model we have developed to help analyze demand for clinical faculty in medical schools. According to that model, the F/S ratio is dependent on funds generated by R and D expenditures and fee income (hereafter denoted as "clinical funds"). Therefore a high F/S ratio should be associated with a high level of funds, and since private schools have higher F/S ratios, we would expect to find higher levels of these funds in private schools than in public schools. As can be seen from Figure 2.6, that is definitely the case. For the period 1971-80, the average level of clinical funds <u>per school</u> was 30 to 60 percent higher in

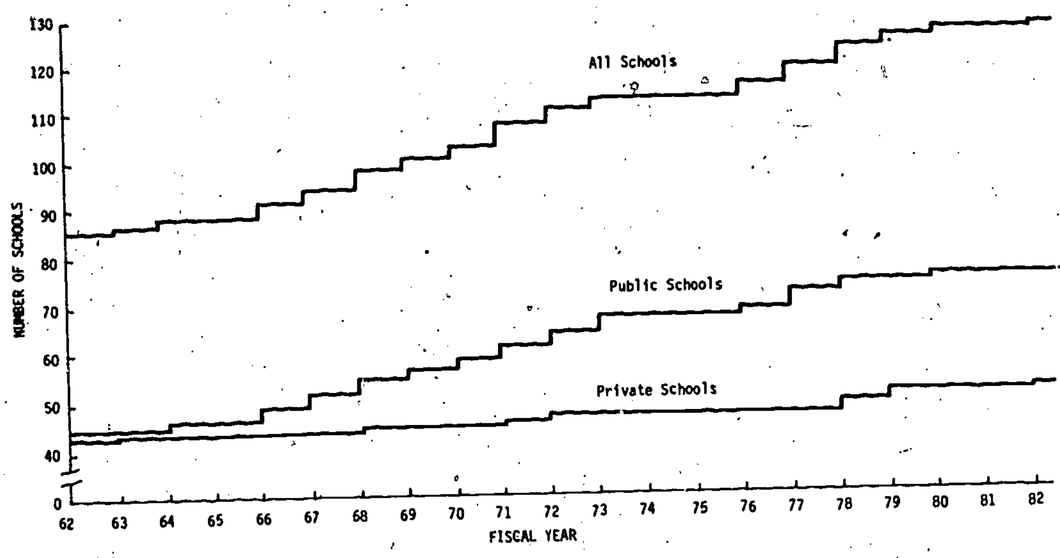

FIGURE 2.2 Number of accredited and provisionally accredited U.S. medical schools, by control of institution, 1962-82. See Appendix Table A4.

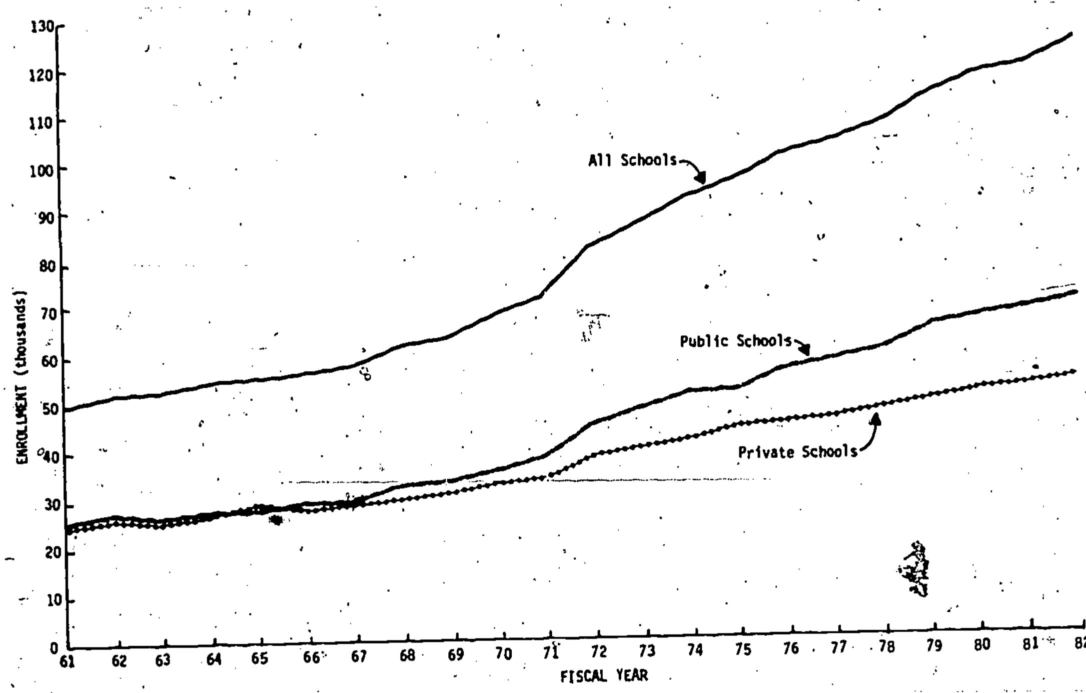

FIGURE 2.3 Medical students, residents, and clinical fellows at U.S. medical schools, by control of institution, 1961-82. See Appendix Table A1.

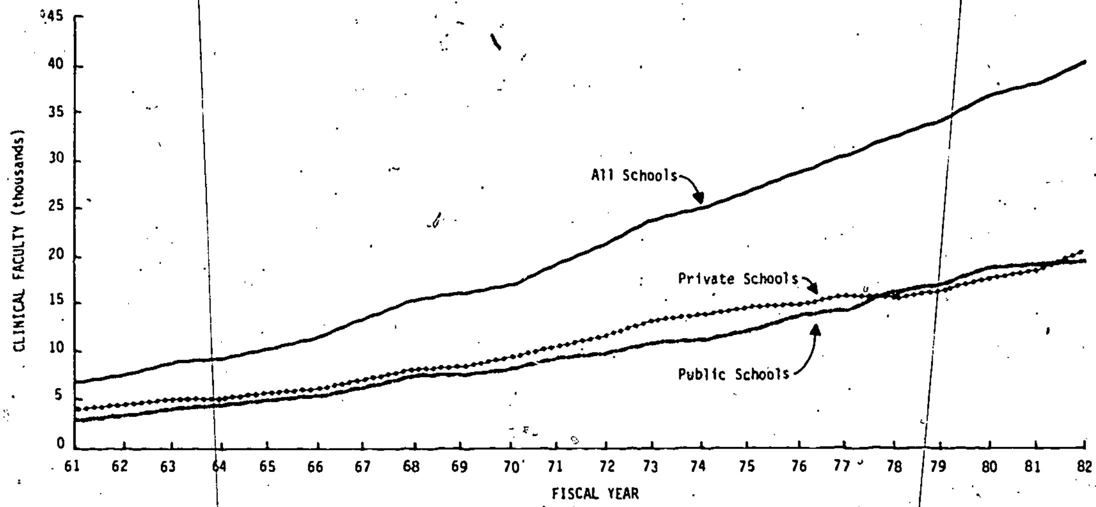

FIGURE 2.4 Full-time clinical faculty in U.S. medical schools, by control of institution, 1961-82. See Appendix Table A2.

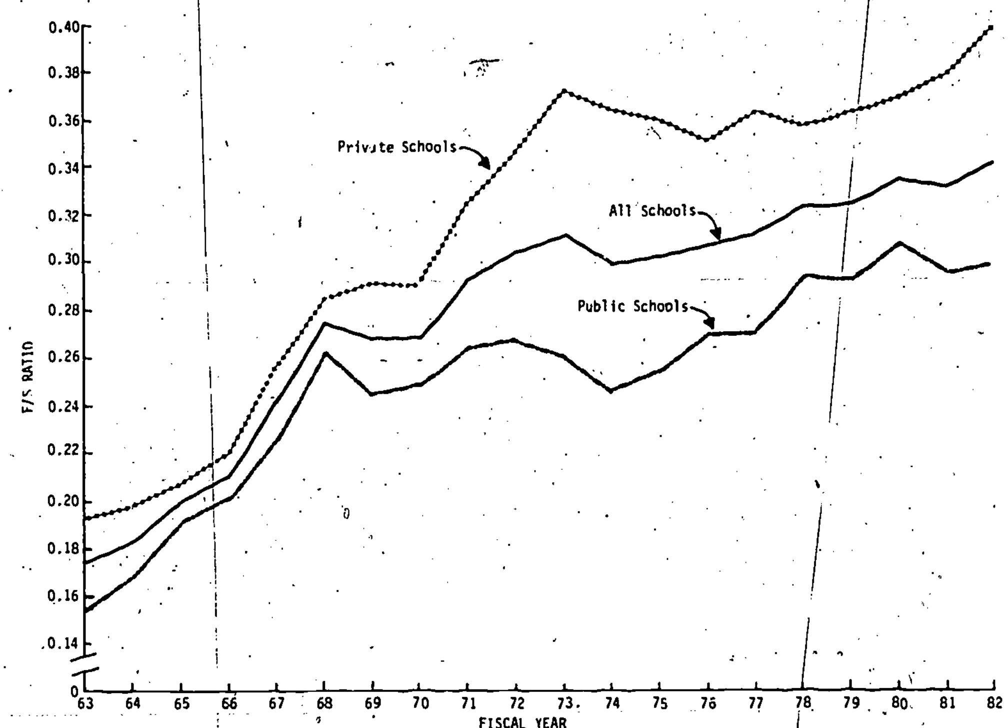

FIGURE 2.5 Ratio of full-time clinical faculty (F) relative to total of medical students, residents, and clinical fellows (S) at U.S. medical schools, by control of institution, 1963-82. See Appendix Table A3.

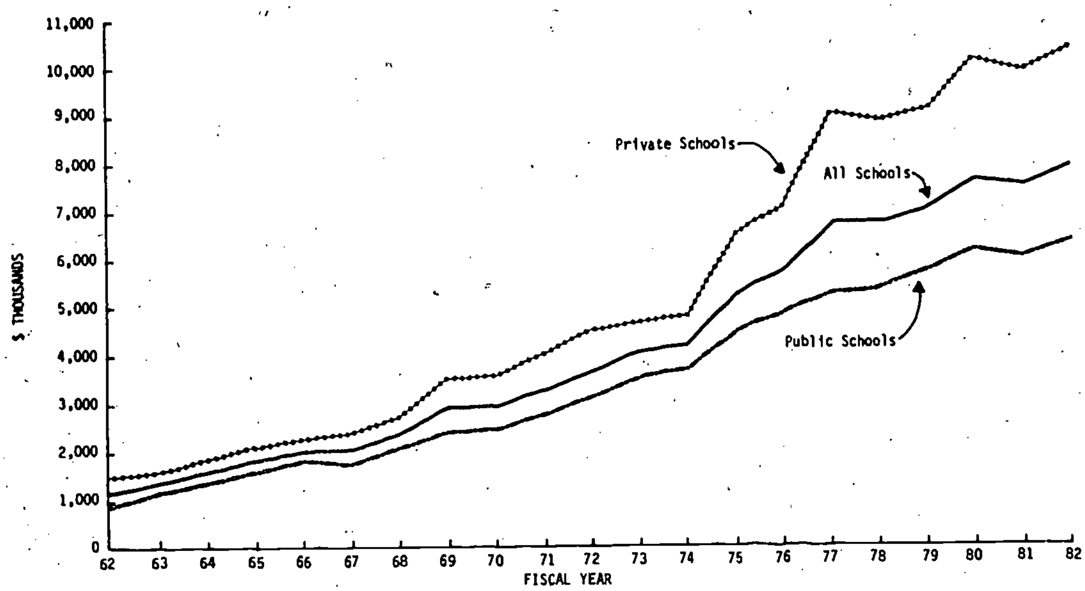

FIGURE 2.6 Average funds per school for clinical R & D expenditures + fee income, by control of institution, 1962-82 (1972 $, thousands). See Appendix Table A9.

private medical schools. During the same period, the private school F/S ratio was 20 to 50 percent higher than the public school ratio.[7]

Data for the period 1962-80 confirm that such a relationship between the F/S ratio and clinical funds does indeed exist for all U.S. medical schools and takes the form of a constrained growth model--the F/S ratio rose rapidly in the 1960s at low levels of clinical funds and less rapidly in the 1970s at higher levels of clinical funds (Figure 2.7). The flattening of the curve in recent years is probably due to rapidly rising indirect costs which generally siphon funds away from faculty support.

In past reports, we have constructed the F/S ratio using annual values of F and S. This year we have modified the ratio such that the denominator is a weighted average of the last four annual values of S. The rationale for this modification is the belief that faculty size does not change in response to changes in current year

[7] Faculty is defined in this model as full-time faculty in clinical departments, while students are defined as the total of medical students, residents, and clinical fellows.

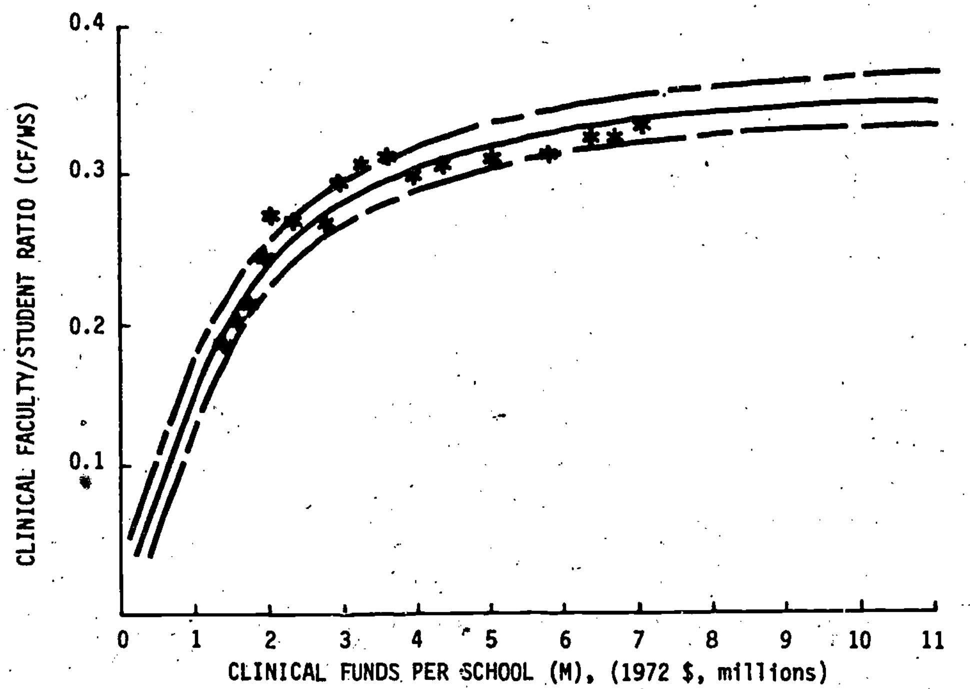

FIGURE 2.7 Clinical faculty/student ratio (CF/WS) vs. clinical funds per school (M) for all medical schools. The ratio is defined as follows: CF = full-time faculty in clinical departments of U.S. medical schools; WS = 4-year weighted average of students, i.e., $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = total of medical students, residents, and clinical fellows. Clinical funds are defined as clinical R & D expenditures (R) plus professional service income (P) in medical schools. M is defined as a 3-year weighted average of R+P: $M_t = 1/4[(R+P)_t + 2(R+P)_{t-1} + (R+P)_{t-2}]$. Solid line represents a growth curve of the form Y = exp (a-b/x)+c fitted to the data for 1964-80. Parameter values are: a = -0.98517, b = 983.18, c = 0.01. Broken lines represent 95% confidence limits on the fitted curve. See Appendix Tables A3 and A9.

enrollments, but that the effect is spread over several years. We use a growth function of the following form to model these data:

$$CF/WS = e^{a-b/M} + c$$

where: CF = full-time clinical faculty in U.S. medical schools

WS = 4-year weighted average of students, i.e., $(WS)_t = 1/6\ (S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$ where S = total of medical students, residents, and clinical fellows

M = 3-yr. weighted average of clinical R and D expenditures plus professional service income per school (1972 $, millions)

c = scaling constant: CF/WS = c when M = 0

a,b = parameters to be determined empirically

With this type of growth function, the percentage change in CF/WS is assumed to increase proportionately to $1/(M^2)$. The function has an inflection point at b/2 and is asymptotic to e^a.[8]

Similar curves also were derived separately for public and private medical schools. These are shown in Figure 2.8 along with the 95 percent confidence limits in each case.[9]

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[8] Fitting this model to data from 1964-80, we get the following estimates for the parameters: a = -0.98517; b = 0.9832; c = 0.01. The values were derived from 17 annual observations by a least-squares regression procedure which yields an R^2 of 0.93^2. R^2--the coefficient of determination--must lie between 0 and 1 and is a measure of how well the assumed function fits the data, with $R^2 = 1$ representing a perfect fit. The dotted lines in Figure 2.7 represent the 95 percent confidence limits on the estimated curve. The curve is asymptotic to CF/WS = 0.38 and has an inflection point at M = $0.5 million per school.

[9] The functional form of these curves is the same as before (although with different parameter values), i.e.: $CF/WS = e^{a-b/M} + c$. Parameter estimates for each case were also derived from 17 annual observations between 1964 and 1980. These are as follows:

Public schools	Private schools
a = -1.266	a = -0.8088
b = 0.8691	b = 1.2892
c = 0.05	c = 0
R^2 = 0.84	R^2 = 0.93

Note in Figure 2.8 that at low levels of clinical funds--below $2 million per school for example--the CF/WS ratios in both public and private schools are quite similar. At levels above $2 million per school, the ratios diverge, with private schools having substantially higher ratios for the same level of clinical funds. This implies a difference in emphasis between public and private medical schools with regard to the way clinical funds are expended. One hypothesis is that private schools tend to use the funds more for faculty support while public schools tend to use the funds more for other purposes.

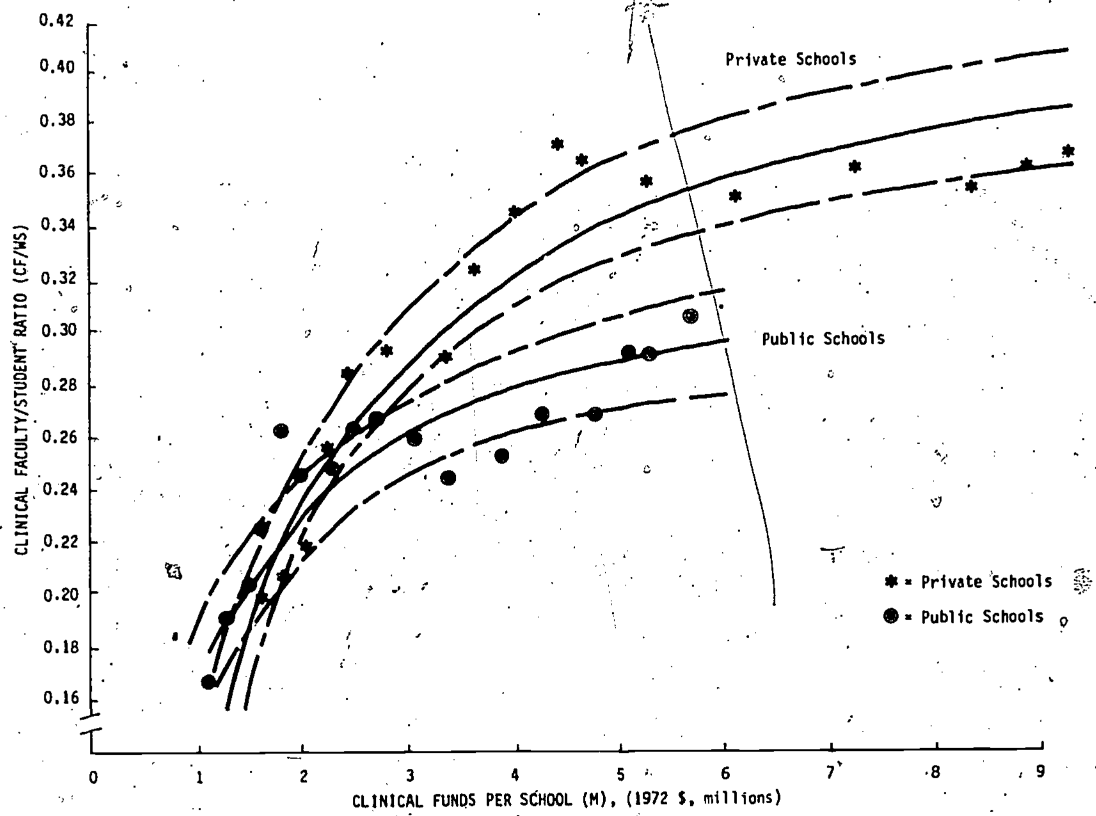

FIGURE 2.8 Clinical faculty/student ratio (CF/WS) vs. clinical funds per school (M), by control of institution. The ratio is defined as follows: CF = full-time faculty in clinical departments of U.S. medical schools; WS = 4-year weighted average of students, i.e., $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = total of medical students, residents, and clinical fellows. Clinical funds are defined as clinical R & D expenditures (R) plus professional service income (P) in medical schools. M is defined as a 3-year weighted average of R+P: $M_t = 1/4[(R+P)_t + 2(R+P)_{t-1} + (R+P)_{t-2}]$. Solid line represents a growth curve of the form $Y = \exp(a-b/x)+c$ fitted to the data for 1964-80. Broken lines represent 95% confidence limits on the fitted curve. See Appendix Tables A3 and A9.

Assumptions

To use the model for projections, it is necessary to make assumptions about the future behavior of the three elements that drive the model--students, R and D funding, and professional fee income.

1. Enrollments: medical school enrollments, defined as medical students, residents, and clinical fellows, are expected to show no growth between 1982 and 1988. The upper and lower limits on the expected growth rate are +2.5 percent per year and -2.5 percent per year, respectively (see Figure 2.9).

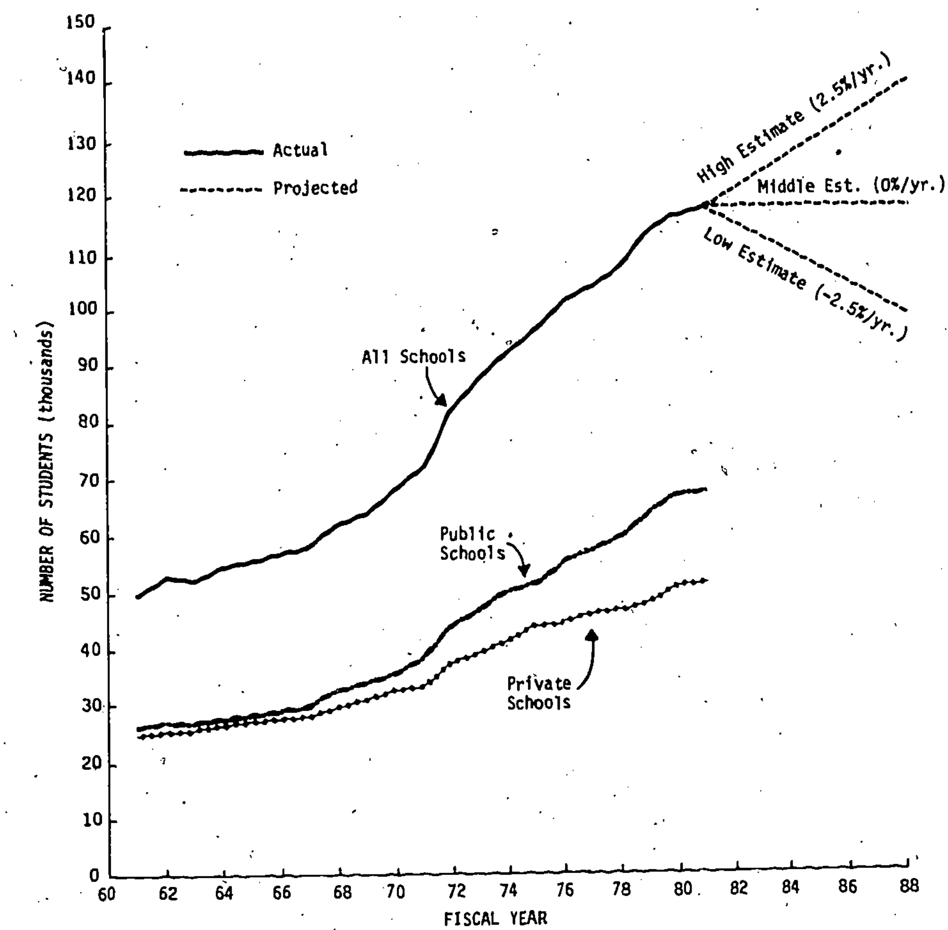

FIGURE 2.9 Medical students, residents, and clinical fellows, by control of institution, 1961-81, with projections to 1988. See Appendix Table A1.

2. Clinical R and D expenditures: the best-guess assumption is for a 2 percent per year growth in these expenditures between 1981 and 1988 after adjusting for inflation. The upper and lower limits are 4 percent per year and 0 percent per year, respectively (see Figure 2.10).

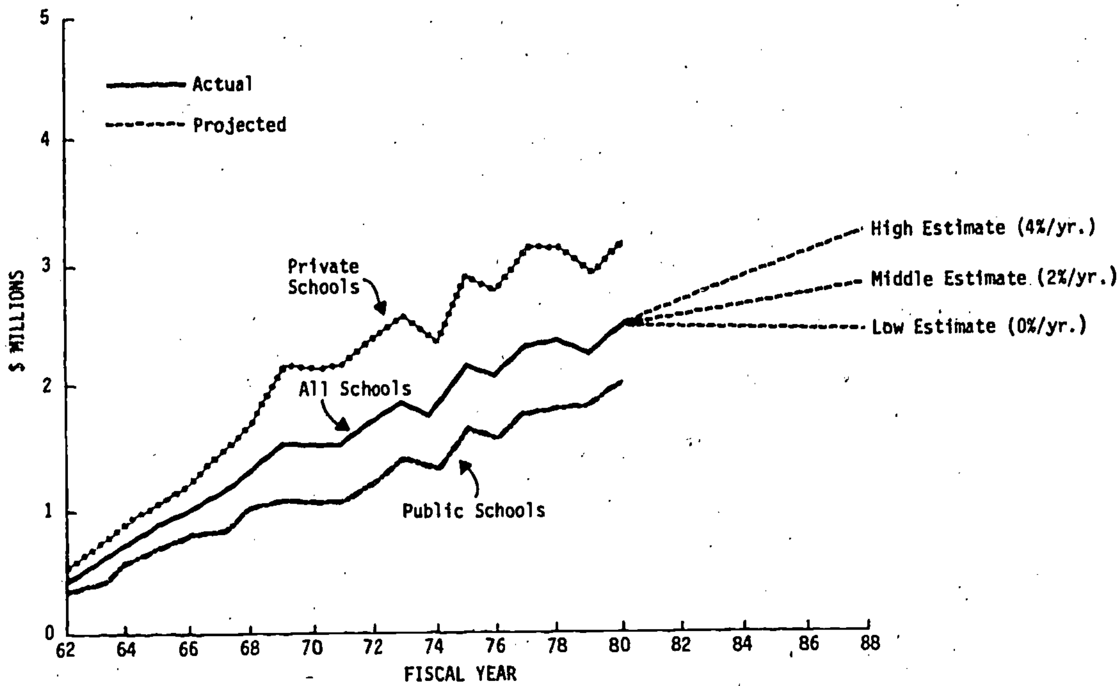

FIGURE 2.10 Clinical R & D expenditures per school in U.S. medical schools, by control of institution, 1962-80, with projections to 1988 (1972 $, millions). See Appendix Table A9.

3. Professional service income: the best-guess assumption is for real growth (after adjusting for inflation) of 2 percent per year from 1982 to 1988. Expected upper and lower limits are 5 percent per year and -1 percent per year, respectively (see Figure 2.11).

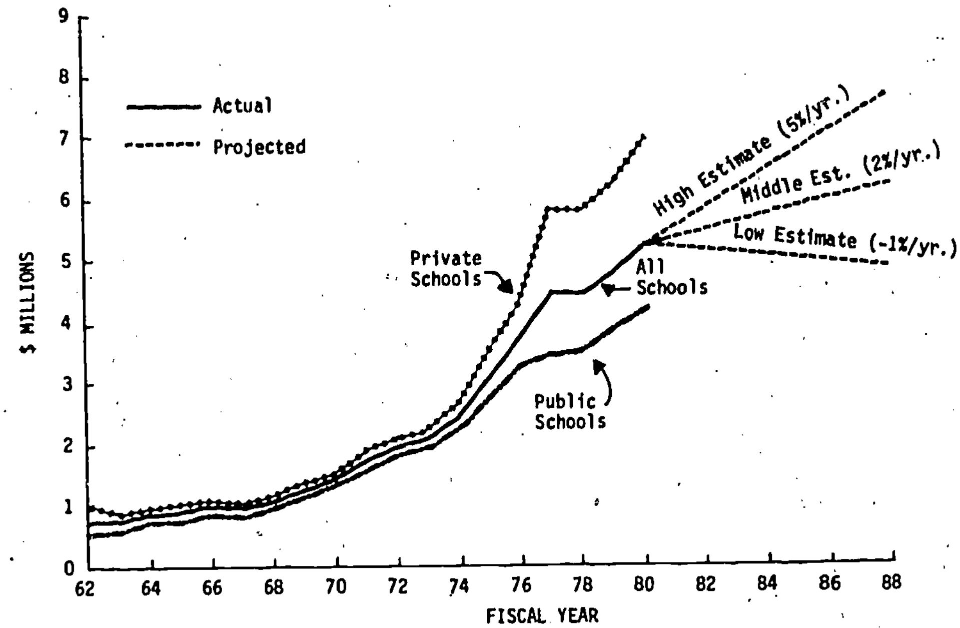

FIGURE 2.11 Professional income per school reported by U.S. medical schools, by control of institution, 1962-80, with projections to 1988 (1972 $, millions). See Appendix Table A9.

Projections of Demand for Clinical Faculty to 1988

Given the Panel's assumptions about enrollments, clinical R and D expenditures, and professional income in medical schools, we now use the model to make projections of demand for clinical faculty. Following our usual practice, projections are made for about 5 years ahead of the report, so this year the projections go through 1988 as shown in Figure 2.12 and Table 2.5.

Under the most optimistic assumptions about clinical R and D expenditures and professional income (assumption I in Table 2.5), these aggregated clinical funds would grow by 4.7 percent per year through 1988 to about $11 million per school, driving the CF/WS ratio to 0.35 from its current value of 0.33. The 98 percent confidence limits on this estimate are 0.366 and 0.334, respectively. Since the most optimistic assumptions attempt to define an upper limit on our projections, we use the upper 95 percent confidence limit on CF/WS (0.366) as the most optimistic estimate. We project academic demand by using the most optimistic estimate of enrollment growth--2.5 percent per year (assumption A of Table 2.5)--together with the estimated CF/WS ratio of 0.366. This produces an estimated upper limit for clinical faculty size of 49,640 members by 1988, for a faculty growth rate of 3.9 percent per year.

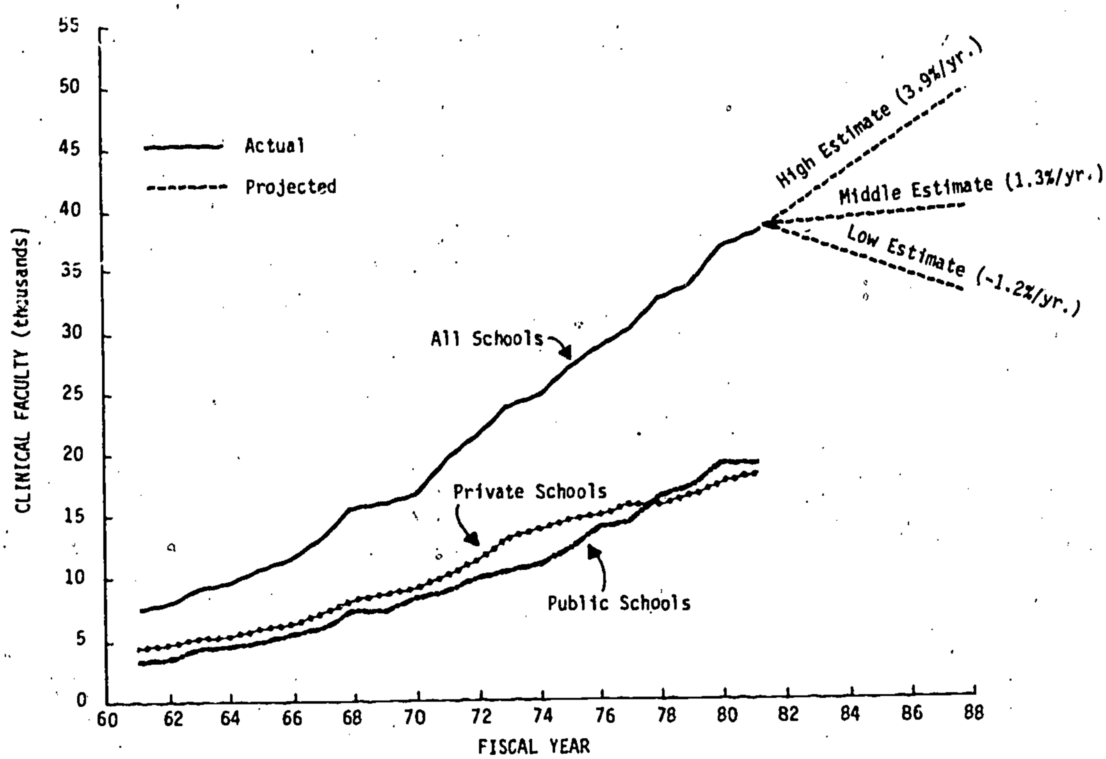

FIGURE 2.12 Clinical faculty in U.S. medical schools, by control of institution, 1961-81, with projections to 1988. Faculty is defined here as full-time appointments in clinical departments regardless of tenure status. See Appendix Table A2.

About 1,620 positions would be created by expansion, with another 430 created by attrition due to death and retirement, and 1,900 created by other faculty attrition. The total number of clinical faculty positions that would become available each year under these high growth asssumptions is estimated at 3,950.

Under the middle or best-guess assumptions (II-B of Table 2.5), clinical funds would expand by about 2 percent per year through 1988--yielding a CF/WS ratio of 0.344--and enrollments would remain at 1981 levels. The best estimate of clinical faculty size under these assumptions is 40,700, an increase of 500 positions per year or 1.3 percent per year over the 1980 level. Attrition from all causes would add another 2,090 positions to give an estimated total annual demand for clinical faculty of 2,590. This is the Committee's most likely projection.

Under the low growth assumptions (III-C of Table 2.5), clinical funds would expand very slightly to about $0.7 million per school by 1988. Consequently, the estimated CF/WS ratio would be 0.336 with upper and lower 95 percent confidence limits of 0.350 and 0.323, respectively. Using the lower estimate of 0.323 to represent the most pessimistic conditions, together with the lowest enrollment growth

TABLE 2.5 Projected Growth in Medical School Clinical Faculty, 1980-88, Based on Projections of Medical School Enrollment, Clinical R and D Expenditures, and Medical Service Income in Medical Schools[a]

Assumptions about Medical Student Enrollment (medical students, residents, and clinical fellows) (118,300 in 1981)		Assumptions about Real R and D Expenditures and Professional Service Income (in constant 1972 dollars[b]) in Medical Schools ($7.6 million per school in 1980)		
		I Will expand at about 4.7%/yr. to $11.0 million per school in 1988	II Will expand at about 2.0%/yr. to $8.9 million per school in 1988	III Will decline slightly by about 0.7%/yr. to $7.2 million per school in 1988
A. Will grow at 2.5%/yr., reaching 141,000 students by 1988	Expected size of clinical faculty in medical schools (CF) in 1988	49,640	46,600	43,800
	Annual growth rate in CF from 1980 to 1988	3.9%	3.0%	2.2%
	Average annual increment due to faculty expansion	1,620	1,240	890
	Annual replacement needs due to:[c]			
	death and retirement	430	420	400
	other attrition	1,900	1,830	1,770
	Expected number of positions to become available annually on clinical faculties	3,950	3,490	3,060
B. Will show essentially no growth from 1981 to 1988, remaining at 118,300 students	Expected size of clinical faculty in medical schools (CF) in 1988	43,300	40,700	38,200
	Annual growth rate in CF from 1980 to 1988	2.1%	1.3%	0.5%
	Average annual increment due to faculty expansion	830	500	190
	Annual replacement needs due to:[c]			
	death and retirement	400	390	370
	other attrition	1,760	1,700	1,650
	Expected number of positions to become available annually on clinical faculties	2,990	2,590	2,210
C. Will decline by 2.5%/yr. to 99,100 students by 1988	Expected size of clinical faculty in medical schools (CF) in 1988	37,700	35,400	33,200
	Annual growth rate in CF from 1980 to 1988	0.3%	-0.4%	-1.2%
	Average annual increment due to faculty expansion	-130	-160	-430
	Annual replacement needs due to:[c]			
	death and retirement	370	360	350
	other attrition	1,640	1,590	1,540
	Expected number of positions to become available annually on clinical faculties	2,140	1,790	1,460

[a]Faculty in this table is defined as a full-time appointment in a clinical department regardless of tenure status. These projections are based on the following relationship:

$(CF/WS)_t = \exp(-1.6813 - 1108.8/D_t) + 0.05$, where CF = size of clinical faculty in medical schools; WS = weighted average of last 4 years of enrollments, i.e., $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = medical students, residents, and clinical fellows; D = weighted average of last 3 years of clinical R and D expenditures plus medical service income per school, i.e., $D_t = 1/4(D_t + 2D_{t-1} + D_{t-2})$. See Appendix Tables A1, A3, and A10.

[b]Deflated by the implicit GNP Price Deflator, 1972 = 100.0. See Appendix Table A7.

[c]Based on an estimated replacement rate of 1.0% annually due to death and retirement, and 4.4% annually due to other attrition. See AAMC (1981a).

assumption of -2.5 percent per year, we estimate clinical faculty size under the worst-case conditions to be about 33,200 members--a decrease of 430 positions per year from 1980 levels. But attrition would create an estimated 1,890 positions per year for a minimum net demand of 1,460 positions.

Estimating Postdoctoral Support Levels Under NRSA Programs

The final step in our quantitative analysis of the market is to attempt to translate the projections of academic demand into recommended levels of postdoctoral training under NRSA programs. This step requires certain additional assumptions about how the system has functioned in recent years with regard to postdoctoral training and its sources of support.

The features of the system that must be considered in addition to the projections of medical school faculty growth are as follows:

1. contributions to academic demand generated by:
   a) the need to reduce budgeted vacancies in clinical departments
   b) demand for clinical faculty in dental and veterinary schools
2. the number of accessions to clinical faculty positions who have (or should have) research training
3. the appropriate length of the research training period
4. the proportion of individuals in the research training pipeline who aspire to academic careers
5. the proportion of support of the total pool of clinical research trainees that should be provided by the federal government.

In the absence of complete knowledge of the system, we must make additional assumptions about these features--first presented in the Committee's 1981 report--in order to provide a quantitative basis for the recommendations.

Using the projections of academic demand derived in Table 2.5, and the same set of conditions specified in the 1981 report, we calculate in Table 2.6 the range of clinical science postdoctoral trainees that should be supported by NRSA programs under the specified conditions.

Line 1 of Table 2.6 is a summary of the projections of academic demand for the extreme cases and the best-guess estimate derived in Table 2.5.

Line 2 is an estimate of the demand generated by the need to reduce budgeted vacancies in clinical science departments of medical schools.

Line 3 provides an estimate of the demand for clinical faculty in veterinary and dental schools--estimated at 16 percent of medical school demand.

Line 4 shows the total annual demand for clinical faculty under each set of conditions. Total annual academic demand is expected to be between 1,860 and 4,750 positions with a best guess of about 3,170 positions.

TABLE 2.6 Estimated Number of Clinical Research Postdoctoral Trainees Needed to Meet Expected Demand for Clinical Faculty Through 1988 Under Various Conditions

	Projected Through 1988			Annual
	High Estimate	Middle Estimate	Low Estimate	Average 1979-81
1. Demand for full-time clinical faculty–annual average:	3,950	2,590	1,460	3,780
a. due to expansion of faculty	1,620	500	-430	1,830
b. due to death and retirement[a]	430	390	350	360
c. due to other attrition[b]	1,900	1,700	1,540	1,590
2. Demand created by unfilled positions[c]	170	170	170	
3. Demand for veterinary and dental school clinical faculty (16% of med. school demand)[d]	630	410	230	
4. Total annual accessions (expected demand)	4,750	3,170	1,860	
5. Total accessions with postdoctoral research training–annual average (assuming 35% of all accessions have postdoctoral research training)[e]	1,660	1,110	650	
6. Size of clinical science postdoctoral pool–annual average				3,000-5,000
Size needed to meet academic demand assuming a 2-yr. training period and portion of trainees seeking clinical faculty positions is:				
a. 60%	8,300	3,700	2,170	
b. 50%	9,960	4,440	2,600	
7. Annual number of clinical science postdoctoral trainees to be supported under NRSA programs:				2,866
a. if 50% of pool is supported under NRSA	4,150-4,980	1,850-2,220	1,080-1,300	
b. if 60% of pool is supported under NRSA	4,980-5,980	2,220-2,660	1,300-1,560	

[a] Assumes an attrition rate due to death and retirement of 1.0% per year. See AAMC (1981a).
[b] Assumes an attrition rate due to other causes of 4.4% per year. See AAMC (1981a).
[c] In 1981 there were 2,231 budgeted vacancies in clinical departments of medical schools. The demand for clinical faculty generated by the need to reduce this level to 1,000 by 1988 is about 170 per year.
[d] In 1978 there were 3,544 full-time clinical faculty members in U.S. dental schools and an estimated 1,869 full-time equivalent clinical faculty members in U.S. schools of veterinary medicine. This total (5,413) was 16% of the full-time clinical faculty in U.S. medical schools. Thus, the demand for dental and veterinary school clinical faculty is estimated at 16% of medical school demand, or 410 per year.
[e] Accessions are defined as new hires or those who rejoin faculties from nonfaculty positions. Interfaculty transfers are not counted as accessions. Data on the percentage with postdoctoral research training were derived from newly hired faculty members only, which are 85% of total accessions. We are assuming that the same percentage applies to all accessions.

SOURCE: Table 2.5.

Line 5 shows the number of clinical faculty positions to be filled by individuals with postdoctoral research training experience assuming that 35 percent of all accessions to academic positions will be former postdoctoral trainees. In the best-guess case, this number is estimated to be 1,110.

Line 6 indicates the size of the clinical science postdoctoral pool required to supply the necessary number of individuals with postdoctoral training under certain assumptions about the length of the postdoctoral training period and the proportion of the pool seeking academic employment.

If the appropriate length of postdoctoral research training in the clinical sciences is 2 years, then the pool size needed to produce 1,110 trained scientists each year would be 2,220. If only 50 percent of the trainees seek academic appointments after completing their training, then the necessary pool size must be 4,440. We assume that some support for postdoctoral research training is also available from sources other than the NRSA programs. This is dealt with in line 7 of this table.

Line 7 shows the estimated number of clinical science postdoctoral trainees that should be supported annually by NRSA programs under different assumptions about the proportion of total support provided by that source. The resulting range is between 1,080 under the lowest set of assumptions, and 5,930 under the highest set. The best-guess assumptions yield a range of 1,850-2,660 postdoctoral trainees in the clinical sciences.

Long-Term Considerations

The foregoing analysis is an attempt to translate the Committee's assessment of enrollments and funding in the next few years into projections of academic demand for clinical faculty and ultimately into training levels needed to satisfy that demand. Along the way we are forced to make critical assumptions about how the system has worked in the past and how it will work in the future. Clearly, the end results are quite sensitive to these assumptions.

In effect, what has been done is to combine expert judgment of future trends with a conceptual view of how the training system operates and how clinical investigators are absorbed into academic positions.

Although we may have identified in this analysis most of the important features of the system that must be considered--attrition rates, length of training period, proportion of support provided by federal programs, for example--our knowledge of all the parameter values in the system is admittedly incomplete. In recognition of this, we have provided a fairly wide range of estimates. This is partly a reflection of incomplete knowledge, but also reflects the uncertainty inherent in any projection exercise.

These caveats notwithstanding, it seems clear that even under the most optimistic set of assumptions made by the Committee, the size of the clinical faculty in U.S. medical schools will not expand as fast as it has in the recent past.

The long-term problem then becomes one of how to maintain the flow of qualified new entrants into the field of clinical investigation in the face of declining opportunities in the academic sector where most clinical research is conducted. It is a basic premise of this Committee that the maintenance of such flow is vital to the research enterprise. A potential no-growth situation in medical schools will tend to decrease this flow as well as the growth of clinical research itself. This dilemma is created by both demographic and economic factors. A projected surplus of physicians has served to preclude further expansion of medical education for the next 10 years or so. Economic conditions are not favorable for large increases in R and D funding by the federal government. The ability of medical school faculties to support themselves through revenue from practice plans will be negatively affected by efforts to contain costs in medicare and medicaid programs. This is the situation facing clinical research as seen by the Committee and other observers. Victor Fuchs, a noted health economist wrote recently:

> "I am particularly concerned, for example, about what will happen to medical research. Without research, without advancing the state of knowledge, medicine will begin to run up against blank walls. There is only a limited amount of improvement in health that can be purchased by increasing the number of physicians or by adding hospital beds. The great advances have always come from figuring out better and newer ways of preventing or treating disease. Somehow there has to be enough funds generated in medical centers to support research and to employ faculty who are actively engaged in research." (Fuchs, 1982)

As noted earlier in this report (Chapter 1), this Committee believes that the long-term problems facing clinical research will arise more from insufficient funding of research than from a lack of training opportunities. We agree with Fuchs when he says that ways must be found in medical schools to support research activities. But we have tried in this report to make the most realistic analysis possible with the existing information. Our recommendations for training in the clinical sciences acknowledge the continuing need to attract and train physicians for research careers. Yet the overall recommended level of training in the clinical sciences has been formulated under our best judgment about the research opportunities that are expected to become available within the next few years under the <u>most likely</u> set of circumstances in medical education.

3. Basic Biomedical Sciences

Bioscience Ph.D. production has been essentially level since 1972 and can be expected to start dropping as a result of declining graduate enrollments. Consequently, the rapid growth in the number of biomedical scientists serving in postdoctoral positions during the 1970s is expected to level off in the 1980s. Nonacademic demand, especially in the new biotechnology industry, is expected to be strong, but the universities will continue to be counted on to supply the training. Students entering graduate school today will be completing their training in the 1990s when long-term demographic trends will begin to change again. Both short-term and long-term projections indicate the need to sustain the current level of support for both predoctoral and postdoctoral training in the basic biomedical sciences.

INTRODUCTION AND OVERVIEW

In this chapter we discuss the national needs for research personnel in the basic biomedical sciences and the supply available to meet these needs. From the most recent data and from the extensive experience of Committee and Panel members are derived recommendations for the numbers of predoctoral and postdoctoral trainee and fellowship awards to be provided under the National Research Service Awards Act during the next 5-year period.

One of the Committee's most important tasks is the collection and analysis of the latest data on enrollments, degrees, R and D funding, and employment for doctorate-level scientists. The data in this chapter help to define the supply/demand situation for scientists in the basic biomedical fields as it existed in 1980-81, providing up to 3 additional years of data beyond that reported on by this Committee in 1981.

Perhaps the most important trends shown by the recent data involve two variables to which the system is highly sensitive--postdoctoral

appointments and enrollments. Following a trend that began in the early 1970s, the number of biomedical scientists serving on postdoctoral appointments increased 5 percent per year between 1979 and 1981 (Table 3.1). This growth occurred during a period in which Ph.D. production was essentially constant. But the rate of growth in postdoctoral appointments appears to have slowed somewhat in 1981, and as the analyses in this chapter will show, there is reason to expect this growth to continue to moderate in the near future.

As for enrollments in the basic biomedical sciences, it is clear that they have leveled off after a long period of steady growth since 1960. Estimated undergraduate enrollment reached a peak in 1976 and dropped for 3 years in a row before rebounding somewhat in 1980. Bioscience baccalaureate degrees have been declining since 1976, and bioscience graduate enrollments reached a peak in 1978. As of 1982, enrollment in medical schools was still growing at less than 2 percent per year, but preliminary data for FY 1983 show practically no growth.

Biomedical science R and D funding in colleges and universities has continued to advance at approximately 4 percent per year (after adjusting for inflation). Research grant expenditures by the NIH declined in FY 1981, after gaining almost 5 percent per year in real terms since 1975. A similar pattern was exhibited by total national expenditures for health related R and D.

The total Ph.D. labor force of biomedical scientists approached nearly 70,000 individuals in 1981, with just over half employed by academic institutions. Academic employment has been increasing by more than 4 percent a year. Employment in the industrial sector is growing much faster, and self-employment is the fastest growing category. The unemployment rate remains low at just over 1 percent.

This report contains recommendations based on both short-term and long-term considerations. Our main objective is to promote a stable system in which biomedical scientists are trained and absorbed into productive research positions. For this we must take a long-term look at the system, including trends in graduate school enrollment and the age profile of university faculty members. Consideration of these and other factors point to a decreasing supply of bioscientists and an increasing attrition rate from the active pool of researchers in the 1990s. In the shorter term, the supply of trained individuals appears adequate although heavy industrial recruitment, particularly in areas related to biotechnology, may create shortages in some disciplines.

We will return to the supply/demand outlook for biomedical scientists later in this chapter after discussing the predoctoral and postdoctoral training systems for these scientists.

THE TRAINING SYSTEM IN BIOMEDICAL SCIENCE FIELDS

In this section, the stages in the career of young biomedical scientists are described to assist in understanding the system in which they are trained in this country. These stages are shown in Figure 3.1. Data in the diagram are the average numbers of scientists

TABLE 3.1 Current Trends in Supply/Demand Indicators for Biomedical Science Ph.D.s

	Fiscal Year							Growth Rate from 1975 to Latest Year	Latest Annual Change	Average Annual Change from 1975 to Latest Year
	1975	1976	1977	1978	1979	1980	1981			
1. SUPPLY INDICATORS (New Entrants):										
a. Ph.D. production	3,515	3,578	3,465	3,516	3,644	3,823	3,838	1.5%	0.4%	54
b. % of Ph.D.s without specific employment prospects at time of graduation	6.4%	6.3%	7.2%	6.0%	5.2%	4.8%	5.5%	-2.4%	14.6%	-0.2%
c. Postdoctoral appts.	5,484	n/a	6,403	n/a	7,419	n/a	8,185	6.9%	5.0%[b]	450
d. B.A. degrees awarded	50,493	52,642	51,783	49,701	47,717	45,106	41,476	-3.2%	-8.0%	-1,503
2. DEMAND INDICATORS (R and D Funding):										
a. National expenditures for health-related R and D (1972 $, bil.)	$3.70	$3.81	$3.97	$4.13	$4.31	$4.48	$4.44	3.1%	-0.9%	$0.123
b. Biomedical science R and D expenditures in colleges and universities (1972 $, bil.)	$1.19	$1.26	$1.27	$1.34	$1.35	$1.43	$1.49	3.8%	4.2%	$0.05
c. NIH research grant expenditures (1972 $, bil.)	$0.897	$0.944	$1.00	$1.06	$1.17	$1.20	$1.19	4.8%	-0.83%	$0.05
d. Ph.D. faculty/student ratio[a]	0.058	n/a	0.056	n/a	0.063	0.067(est.)	n/a	3.2%	6.3%	0.002
3. LABOR FORCE:[b]										
a. Total	50,698	n/a	55,167	n/a	62,590	n/a	69,076	5.3%	5.1%	3,063
b. Academic (excl. postdocs.)	28,339	n/a	30,390	n/a	33,687	n/a	36,497	4.3%	4.1%	1,360
c. Business	6,645	n/a	6,918	n/a	8,461	n/a	9,957	7.0%	8.5%	552
d. Government	4,522	n/a	4,567	n/a	5,075	n/a	5,406	3.0%	3.2%	147
e. Hospitals/clinics	1,950	n/a	2,296	n/a	2,727	n/a	2,798	6.2%	1.3%	141
f. Nonprofit	1,221	n/a	1,544	n/a	1,854	n/a	2,083	9.3%	6.0%	144
g. Self-employed	836	n/a	864	n/a	1,197	n/a	1,860	14.3%	24.7%	171
h. Other (incl. postdocs.)[c]	6,667	n/a	8,642	n/a	8,899	n/a	9,644	6.3%	4.1%	496
i. Unemployed and seeking	518	n/a	810	n/a	690		831	8.2%	9.7%	52
4. BIOMEDICAL ENROLLMENTS:										
a. Graduate	38,314	39,322	39,260	43,787	43,378	42,969	42,117	1.6%	-2.0%	634
b. Medical and dental schools	74,222	77,011	79,279	81,934	84,761	86,502	88,254	2.9%	2.0%	2,339
c. Estimated undergraduate[d]	424,539	439,945	425,863	406,373	374,869	386,236	n/a	-1.9%	3.0%	-7,661
d. Total biomedical graduate and undergraduate enrollment	537,075	556,279	544,402	532,094	503,008	515,707	n/a	-0.8%	2.5%	-4,274

[a] Ratio of academically employed Ph.D.s to a 4-year weighted average of total graduate and undergraduate enrollments (WS), where $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$.

[b] Since labor force data are not available for 1980, latest annual change represents average annual growth rate from 1979-81.

[c] Also includes FFRDC laboratories.

[d] Estimated by the formula $U_i = (A_{i+2}/B_{i+2})C_i$, where U_i = biomedical science undergraduate enrollment in year i; A_{i+2} = biomedical science baccalaureate degrees awarded in year i+2 (excluding health professions); B_{i+2} = total baccalaureate degrees awarded in year i+2; C_i = total undergraduate degree-credit enrollment in year i (excluding first professional).

SOURCES: AAMC (1972-83, special tabulations of 4/8/82 and 5/17/82); ADA (1971-83a); AMA (1960-82); NIH (1966-82); NRC (1958-82, 1973-82); NSF (1973-83a, 1975-83); U.S. Department of Education (1948-83, 1959-79, 1961-82, 1973-82, 1974-82).

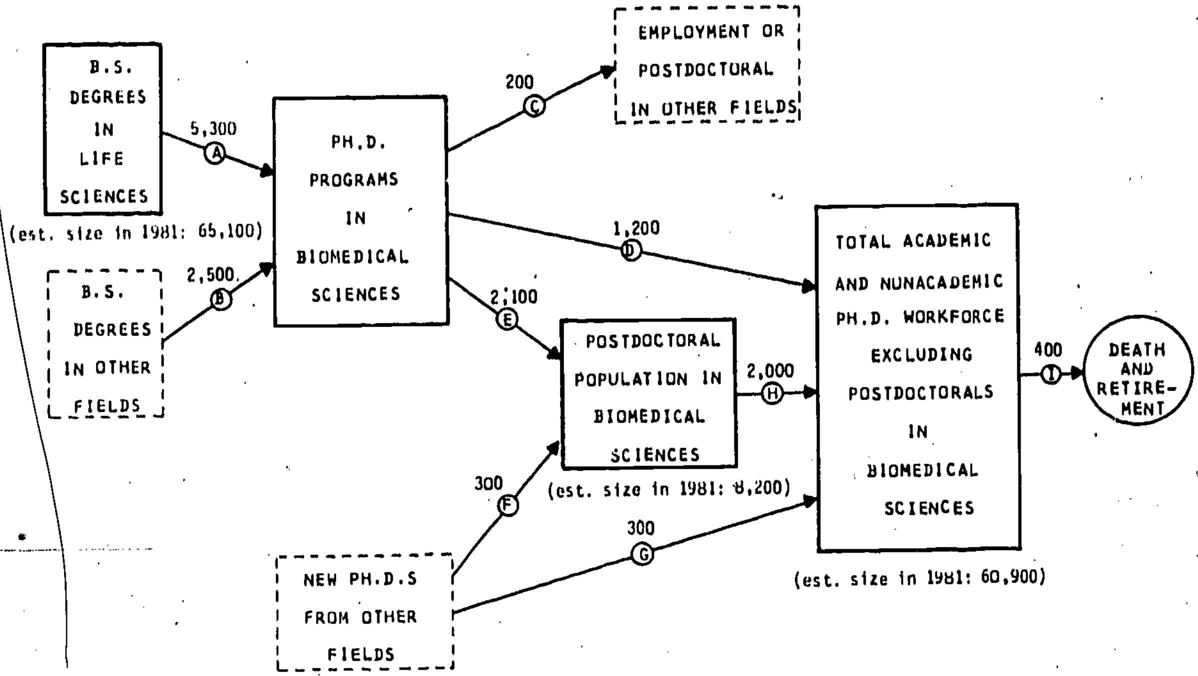

FIGURE 3.1 Doctoral training system in the biomedical sciences. Estimates represent the average annual number of individuals following particular pathways during the 1973-81 period. No estimates have been made for immigration, emigration, or re-entry into the labor force.

each year from 1973-81 who have followed particular routes. Depicted on the left is the incoming supply of baccalaureate degree recipients headed for doctoral training in the biomedical sciences. To the right is the active Ph.D. labor force. Estimates of the pool sizes in 1981 are given where these can be made. During 1973-81, attrition from the labor force due to death and retirement has averaged only 400 scientists a year (path I), while the total number entering has averaged 3,500 scientists annually (paths D, G, and H). Consequently, there has been an annual net growth in the biomedical Ph.D. labor force of approximately 3,100 individuals.

The "training system" may be viewed as a network of interconnected pools, with a flow of trainees from left to right. The flow between pools is determined by the number of individuals having the credentials (and interest) required to enter the next stage in their career development. The transition from one stage to another is influenced by a variety of factors including the trainee's personal career preference, the availability of student financial support, institutional resources (space, supplies, faculty), and institutional admissions policies.

The pathways described in Figure 3.1 represent the available routes to careers in research. Students may leave at any stage, but they must generally re-enter where they withdrew. The route most commonly followed by undergraduates interested in research careers in this field is through doctoral (paths A and B) and postdoctoral training (path E) in the biomedical sciences. Completion of doctoral training may require between 5 and 7 years from receipt of the baccalaureate degree, and Ph.D. scientists typically spend between 2 and 4 years on postdoctoral apprenticeships. Thus, from the time a student enters graduate school to the time he or she completes postdoctoral training may take from 7 to 11 years (with a median of 9 years in postgraduate training).

As shown in the diagram, there are three separate stages through which aspiring young biomedical scientists pass: undergraduate, graduate, and postdoctoral training. Described on the following pages are the features of each phase that affect both the numbers and the quality of young investigators trained to fill the nation's need for research personnel in the basic biomedical sciences.

Undergraduate Training

Most of the undergraduates preparing for research careers in the basic biomedical sciences pursue baccalaureate programs in biology or chemistry, but some also receive their degrees in physics, mathematics, or a social science. Attrition in undergraduate programs is high--an estimated 40 percent of the matriculants do not graduate--and a majority of those who do graduate are either not interested in or do not qualify for graduate study.

The decision to enroll in a doctoral program is influenced by several considerations. Most biology undergraduates plan careers in one of the health professions, and they generally receive very little encouragement to pursue careers in biomedical research--especially since the numbers of faculty openings in this field have diminished in recent years. The availability of federal training grant support may also directly or indirectly affect career decisions by undergraduates. In times when federal funds for graduate training were more plentiful, the staff at research institutions often pursued active recruiting programs that included visits to non-research colleges and the provision of summer research opportunities to sophomores and juniors. In the last few years these efforts have diminished. Furthermore, students considering careers in biomedical research may view the diminishing level of federal training support as an indication that the recruitment of well-qualified investigators into this field is no longer an important national priority.

Doctoral Training

The primary goal of those undertaking graduate study in the basic biomedical sciences is to begin to establish credentials as an

independent investigator. Admission of students into graduate school is usually based on undergraduate grade point average, performance on the Graduate Records Examination (or a comparable test), and faculty recommendations. In many instances considerable weight is also given to the undergraduate research experience of the candidate and a personal interview. During their first 2 years in graduate school, students are expected to take advanced courses in their major area of work and in related areas. There is generally great freedom allowed in the selection of courses so that each individual develops a unique set of skills. After completion of course work, students must pass qualifying examinations (written, oral, or both) and then concentrate on their areas of research interest. A doctoral candidate typically spends between 3 and 4 years (beyond course work) developing skills as an independent investigator. Submission of a doctoral dissertation, describing a significant and original scientific contribution, is a primary requirement for successful completion of the Ph.D. program. Often students present manuscripts based on their research which are accepted for publication in refereed journals.

At every step in the development of a research scientist, new skills are required. As an undergraduate, a student may do very well with a high capacity to memorize and to study. A graduate student must be able to pose questions, devise experiments to answer them, carry out experimental protocols (often devising new procedures and creating new instrumentation or equipment), and manage time in an unstructured environment. The Ph.D. candidate must display creativity and have the motivation to function independently with only limited supervision. The student will succeed only if he or she can work alone and grow in scientific independence. Many doctoral students withdraw because they cannot make the transition from undergraduate to graduate school setting--even though they possess the intellectual capacity required.

Attrition due to academic failure is not common but does occur. Also, some students, having been exposed to the research environment, may reassess their career goals and decide to pursue other interests (e.g., careers in medicine or in other scientific fields). Half the students enrolling in doctoral programs do not complete requirements for the Ph.D.--some terminate study at the master's level--and there is no compensating inflow of replacements for those leaving. This attrition rate has always been high. Neither faculty nor students have a reliable basis for predicting which students have the necessary personal commitment that is essential for completion of the degree. Keeping uncommitted students in the program would be truly wasteful.

While in doctoral training, many students hold teaching assistantships, research assistantships, traineeships, and fellowships and receive an average annual stipend of approximately $6,000. Graduate students are involved in a very large share of the projects sponsored by the NIH, NSF, and other federal agencies funding health-related research. On the average, each student contributes 3-4 years of full-time effort directed toward the elucidation of a carefully selected scientific question. While the proportion of the overall research effort attributable to graduate students cannot be reliably

estimated, it is evident that they play an essential role. Typically, the supervisory faculty member selects the areas of focus for research, obtains the required funding and other resources, provides direction and consultation, but may do little of the actual experimentation or data collection. The last are major responsibilities of the graduate students and postdoctorals, although both play significant roles in the design of experiments as well.

The contribution of graduate students to the leadership position in the biomedical sciences now held by the U.S. must be recognized. If the number of graduate students is decreased, or if fewer stay to complete degrees, research productivity in the basic sciences will be directly diminished. The graduate student contribution cannot be replaced by technicians who generally do not contribute to experimental design. They cannot be replaced by postdoctorals unless the latter category is increased substantially--and that can only be achieved by having more graduate students to feed the postdoctoral pool. Nevertheless it seems essential to face up to the longer-term prospects of a different mix of contributors to the research work force. Smaller numbers of graduate students, larger numbers of postdoctorals, who are better paid and who hold more permanent positions, as well as larger numbers of technicians can be expected.

Postdoctoral Training

An estimated 60 percent of the Ph.D. recipients in the basic biomedical sciences now go on to postdoctoral appointments, and that percentage has been increasing steadily over the past 15 years. Unlike undergraduate and graduate training programs that are the shared responsibility of departmental faculty groups, postdoctoral training is generally the province of individual faculty members. Each member directs the activities of his or her research group, and that group and the interactions among individuals within the group provide the environment for postdoctoral training.

The principal determinants of whether a graduate student pursues postdoctoral training are the career goals of the individual, the opportunity to work with a highly regarded mentor or research team, the availability of attractive employment alternatives, and a variety of personal considerations (e.g., geographic location, financial incentives). For those interested in faculty careers at major research institutions, a minimum of 1-2 years postdoctoral apprenticeship is generally required. Although there is no formal certification attached to the post-Ph.D. training, 3 years is accepted as the standard time needed to achieve the appropriate level of experience. Many young scientists extend their studies to 4 or more years because of interest in a particular project, desire to complete their research and publish the findings, or a lack of alternative employment opportunities.

Although the postdoctoral stipend--ranging from $14,000 to $18,000 per year--is well below the salary paid to a junior faculty member, many young biomedical scientists find the postdoctoral experience

highly rewarding, as witnessed by this passage from a previous NAS study.

> From the perspective of the young investigator the postdoctoral appointment has provided a unique opportunity to concentrate on a particular research problem without the burden of either the teaching and administrative responsibilities usually given to a faculty member or the formal degree requirements of a graduate student. As the competition for research positions has intensified during the past decade, the opportunity as a postdoctoral to establish a strong record of research publications has become increasingly attractive to many young scientists interested in careers in academic research. (NRC, 1981a, p. 82)

Those holding postdoctoral appointments contribute to the quality, creativity, and productivity of the research enterprise. The roles that these individuals play in the research effort depend on the modus operandi of the senior investigator, the nature of the research problem, the size and composition of the research team, departmental and institutional policies, and the talents and experience of the individual. Frequently the importance of the postdoctoral scientist's contribution to the research effort is recognized in his or her inclusion as the principal author of one or more articles based on the findings. Furthermore, many postdoctoral appointees are substantially involved in the training of graduate and undergraduate students.

Following completion of the postdoctoral tenure, most individuals are expected to move on to research positions in academia or in industry and government laboratories. An increasing fraction, however, remain more-or-less permanently employed as senior research associates in the university setting. These scientists are often key members of a research group--providing continuity through the training of new group members and maintaining the research environment and oral history of long-term projects. These senior research associates complement the lead faculty members and provide day-to-day supervision of the laboratories.

EXPANSION OF THE POSTDOCTORAL POPULATION

For several years now the Committee has paid particular attention to changes in the size of the postdoctoral population in the basic biomedical sciences. During the 1973-81 period the number of biomedical scientists holding postdoctoral appointments in universities has climbed at a reasonably constant rate of 9 percent per year--significantly higher than the rate of growth for faculty. The net annual increments to the postdoctoral group have averaged approximately 420 scientists (Figure 3.2), while the total number of Ph.D. graduates each year has increased only slightly.

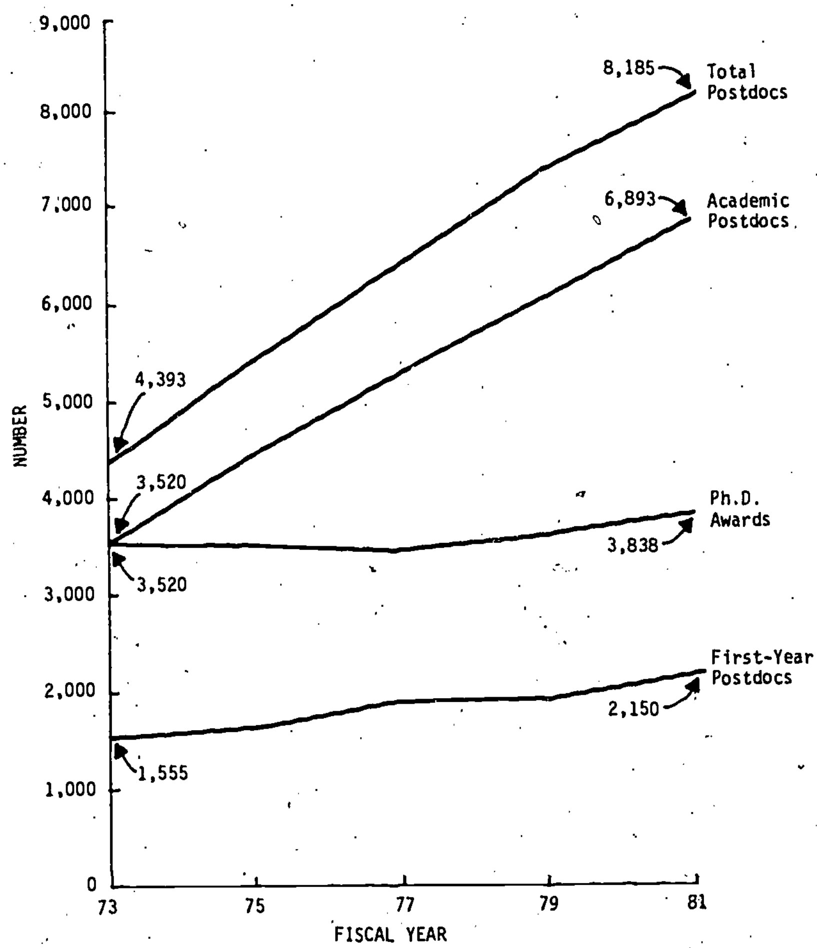

FIGURE 3.2 Estimated growth in the numbers of Ph.D. awards, academic postdoctoral appointments, and first-year postdoctoral appointments in the biomedical sciences, 1973-81. First-year appointments are estimated from the number of Ph.D. recipients each year planning to take postdoctoral training positions in an academic setting after completing their graduate education. See Appendix Table B3.

This postdoctoral growth has important implications for both research and research training in the biomedical disciplines. In terms of numbers, the postdoctoral group constitutes an estimated 18 percent of the full-time equivalent bioscience research personnel in Ph.D.-granting universities (NRC, 1981a, p. 195). Because they bring with them fresh ideas and new techniques and devote their full energies to their scientific investigations, the importance of the postdoctoral group to the quality, creativity, and productivity of

scientific inquiries is much greater than their numbers alone suggest. On the other hand, there is some concern that in recent years more biomedical science graduates have taken postdoctoral appointments than may find career opportunities in research. In an earlier report the Committee found that more than 40 percent of the FY 1971-75 Ph.D. recipients who held postdoctorals in 1976 indicated that they had prolonged their appointments because of difficulty in finding employment positions they desired (NRC, 1975-81, 1977 report, Vol. 2, p. 31). Other evidence presented later in this section reveals that since 1973 a steadily declining fraction of postdoctoral scientists in biomedical fields have subsequently moved on to faculty positions in major research universities.

With this concern in mind the Committee has made a detailed examination of the postdoctoral growth during the 1973-81 period. The analysis has focussed on six questions:

1. What are the principal factors underlying the postdoctoral expansion in the basic biomedical sciences?
2. In which university settings has most of the expansion occurred?
3. Have the demographic characteristics of the postdoctoral population changed significantly during the 8-year period?
4. Do those who have held appointments 4 years or longer differ from other postdoctoral scientists--in terms of their training background and other characteristics?
5. Have the more recent graduates encountered greater difficulty in pursuing careers in research after completing their postdoctoral training?
6. Is the rapid rate of postdoctoral expansion observed the past 8 years likely to continue?

The following examination of these questions relies exclusively on detailed tabulations of data collected in the NRC's biennial (1973-81) Survey of Doctorate Recipients. The survey includes responses from a 15 percent sample of biomedical scientists who had earned their doctorates within the previous 43 years; responses have been weighted to provide population estimates.

Factors Contributing to Postdoctoral Expansion

The steady growth in the postdoctoral population in academia may be attributed primarily to two factors: an increase in the numbers of new Ph.D. recipients pursuing additional research training in the biomedical sciences and an increase in the average length of time individuals spent in postdoctoral apprenticeships. As illustrated in Figure 3.2, the number of first-year postdoctoral appointees is estimated to have grown at a rate of approximately 75 individuals a

year--accounting for two-fifths[1] of the postdoctoral expansion between 1973 and 1981. It may be presumed that the remainder was due to a prolongation of postdoctoral tenure. During this 8-year span the median length of time spent in postdoctoral training increased from 2 to 3 years. Table 3.2 presents data describing the percentages of

TABLE 3.2 Estimated Percent of Biomedical Ph.D. Recipients Entering Postdoctoral Training Immediately After Graduation Who Still Held Appointments 3, 4, and 5 Years Later

	Percent Holding Postdoctorals After:		
Ph.D. Cohort[a]	3 Years	4 Years	5 Years
1967-68			3.9
1968-69		9.8	
1969-70	22.2		10.9
1970-71		19.1	
1971-72	33.5		10.7
1972-73		20.2	
1973-74	42.1		12.1
1974-75		26.8	
1975-76	47.8		22.9
1976-77		32.8	
1977-78	47.1		

[a]Each cohort includes Ph.D. recipients from the 2-year period specified who indicated at the time they completed requirements for their doctorates that they had firm commitments to take postdoctoral appointments.

SOURCES: National Research Council (1958-82, 1973-82).

biomedical Ph.D. recipients taking postdoctoral appointments immediately after graduation who still held training appointments 3, 4, and 5 years later. Recent graduates have typically held postdoctoral appointments for appreciably longer periods of time. For example, as many as 33 percent of the 1976-77 cohort remained in postdoctoral status 4 years later, compared with 10 percent of the 1968-69 cohort. Whether or not these biomedical scientists have extended their apprenticeships because of difficulty in finding employment situations or because of other reasons unrelated to the availability of career opportunities cannot be ascertained from the survey data collected. Nevertheless, it is obvious that the prolongation of apprenticeship (for whatever reason) has been a major factor contributing to the expansion of the postdoctoral population in the biomedical sciences.

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[1] In deriving this fraction it has been estimated that, if there had been no change in average length of postdoctoral apprenticeship, the 1981 postdoctoral population would have included approximately 4,900 biomedical scientists.

Postdoctoral Setting

Further analysis of the 1973-81 growth trends reveals that much of the postdoctoral expansion has occurred within medical schools. In 1981 an estimated 65 percent of the postdoctoral scientists were employed in medical or other health professional schools compared to 56 percent 8 years earlier. Most growth has occurred within the 20 largest research universities, which employed 43 percent of the postdoctoral scientists in 1981 compared with 36 percent in 1973.[2] Throughout this period almost all of the postdoctorals were employed full-time, mainly in R and D activities. Approximately 85 percent were involved in federally-sponsored research activities. This evidence supports the impressions of many Committee and panel members who have observed a steadily growing demand for postdoctoral scientists--especially within the major biomedical research institutions.

Demographic Characteristics

In most respects the demography of the postdoctoral population has changed little during the past 8-year period of growth. Approximately 10 percent of this population, which includes only individuals with doctorates from U.S. universities,[3] held foreign citizenship, and about 30 percent were women. (The fraction of women holding postdoctoral appointments has risen slightly in recent years, along with an increase in the fraction of women earning biomedical science doctorates.) As many as 40 percent of the biomedical postdocs received their graduate training in biochemistry, molecular biology, or microbiology, and less than 5 percent held professional doctorates as well as Ph.D. degrees. As might be deduced from the survey data presented in Table 3.2, there has been a significant shift in the academic age distribution of the postdoctoral group. In 1973 an estimated 17 percent had received their Ph.D.s more than 3 years earlier (Figure 3.3); in 1981 27 percent had earned their degrees more than 3 years before. Similarly, the proportion with more than 4 years postgraduate experience has risen from 12 percent in 1973 to nearly 20 percent in 1981. This change may be attributed, of course, to the prolongation of postdoctoral apprenticeships by many recent graduates.

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[2] These 20 institutions received approximately 38 percent of the federal funding in the biological sciences in FY 1980; for a list of these 20, see National Science Foundation, 1975-83, FY 1980, pp. 79-80.
[3] It is estimated that foreign scientists have comprised approximately one-third of the total population of biomedical investigators holding postdoctoral appointments in U.S. university laboratories.

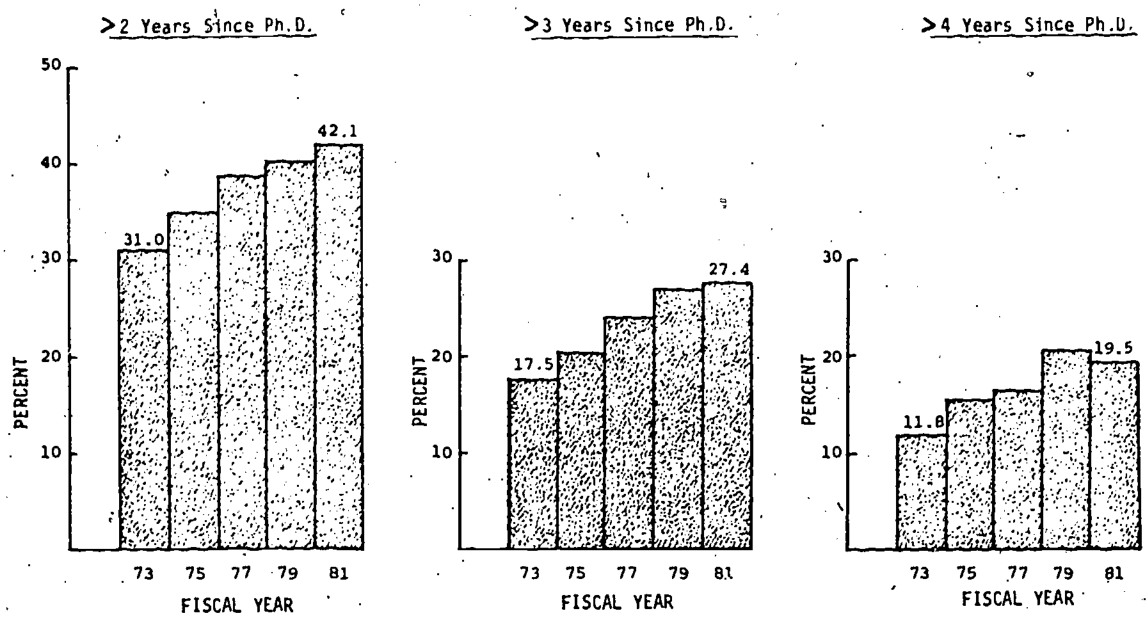

FIGURE 3.3 Percent of the postdoctoral population in the biomedical sciences who had earned their doctorates more than 2, 3, or 4 years earlier, 1973-81. See Appendix Table B17.

Long-Term Postdoctorals

To investigate further the trend toward longer postdoctoral tenures, a comparison has been made between those who had held their training appointments 4 or more years since receiving their Ph.D.s and other postdoctoral scientists in the biomedical disciplines. Some small, but interesting, differences were found between these two groups--in terms of both their employment settings and their demographic characteristics. For example, the senior postdoctoral group was comprised of a disproportionately large share of women (35 percent) and foreign nationals (16 percent). Those holding postdoctorals 4 or more years after completion of their graduate education were also less likely than other postdoctoral scientists to be employed in the 20 largest research universities or to be involved in federally-sponsored research. None of these differences, however, are of sufficient magnitude to be considered of major import. Nor is there any evidence to suggest that graduates from the leading doctoral programs were more likely to prolong their postdoctoral apprenticeships than were other biomedical science Ph.D. recipients. This finding seems to confirm the Committee's opinion that the decision to extend postdoctoral training is frequently influenced by personal considerations unrelated to an individual's abilities and talents.

Career Prospects for Postdoctorals

A possible concern with regard to the rapid growth in the postdoctoral population is that there may be a mismatch between the important role these individuals play in the nation's research enterprise and the lack of opportunities they find for subsequent careers in biomedical research. Previous findings by the Committee suggest that career opportunities in academic research are becoming scarcer. What effect has this situation had on the careers of individuals completing their postdoctoral training in the biomedical sciences? To address this issue an analysis has been made of the 1975-81 employment situations of biomedical science Ph.D. recipients who had begun postdoctoral training between 5 and 7 years earlier. Results of this analysis are reported in Table 3.3. In interpreting

TABLE 3.3 Employment Situations of Biomedical Ph.D. Recipients Who Had Entered Postdoctoral Training Between 5 and 7 Years Earlier, 1975-81

Employment Situation		Fiscal Year 1975	1977	1979	1981
Major Research Institutions[a]	N	1,091	1,047	1,130	1,219
	%	49.4	47.0	41.7	43.4
Faculty-Rank Positions[b]	N	876	773	772	763
	%	39.7	34.7	28.5	27.2
Other Staff Positions[c]	N	215	274	358	456
	%	9.7	12.3	13.2	16.2
Other Universities and Colleges	N	526	573	590	622
	%	23.8	25.7	21.8	22.2
Faculty-Rank Positions	N	475	521	480	501
	%	21.5	23.4	17.7	17.9
Other Staff Positions	N	51	52	110	121
	%	2.3	2.3	4.1	4.3
Nonacademic Employment Sectors	N	578	586	957	922
	%	26.2	26.3	35.3	32.9
Research Positions[d]	N	490	476	734	702
	%	22.2	21.4	27.1	25.1
Other Staff Positions	N	88	110	223	220
	%	4.0	4.9	8.2	7.8
Unemployed and Seeking Position	N	16	23	35	43
	%	0.6	1.0	1.3	1.5
TOTAL	N	2,208	2,229	2,712	2,806
	%	100.0	100.0	100.0	100.0

[a]Includes the 100 academic institutions with the largest total R and D expenditures in the biomedical sciences in FY 1979.
[b]Instructor, Associate Professor, Assistant Professor, or Professor.
[c]Includes research staff appointments, postdoctorals, and other nontenure track positions in universities and colleges.
[d]Includes all individuals employed in nonacademic sectors who indicated that they devoted at least one-fourth of their time to R and D activities.

SOURCES: National Research Council (1958-82, 1973-82).

the findings one must keep in mind that the data do not reflect the career patterns of any individuals who started postdoctoral training since 1976. As can be seen from the data presented, there has been an appreciable decline in the percentages of former postdoctorals holding positions with a faculty rank (Instructor and above)--especially those in major research institutions. This decline has been offset in part by increases in the percentages of those employed in non-faculty staff positions in academia (including prolonged postdoctoral training appointments). During this 6-year period there have also been increases in the fraction employed outside the academic sector--and many of these scientists were involved in research activities. Thus, although the findings indicate that a significantly smaller proportion of biomedical science postdoctorals have moved on to university faculty-rank positions, the proportion continuing to pursue careers in research has not changed appreciably.

Future Growth of the Postdoctoral Population

We appear to be approaching a turning point in the size of the postdoctoral population. It seems probable that the number of individuals in this cadre will stabilize in the next few years. Whether it does or not will depend primarily on how many graduates decide to enter postdoctoral training in universities and their average length of apprenticeship. As already mentioned, the rapid postdoctoral expansion of the past occurred during a period when doctoral awards grew at an annual rate of only 1 percent--from 3,520 in FY 1973 to 3,951 in FY 1982. This modest increase in doctorates followed a period of sizeable growth in the numbers of students enrolling in the biomedical sciences. Since 1975, however, first-year graduate enrollments have dropped 20 percent as shown in Figure 3.4. It seems highly probable that this decline will have a corresponding effect on the number of doctoral awards in the next several years, which in turn will reduce the number of new entrants to the postdoctoral population.

For purposes of illustration, projections have been made of the numbers of doctoral awards during the 1982-87 period and the numbers of young investigators expected to enter the postdoctoral population in academia. It is assumed on the basis of data from the Doctorate Records File that 6-1/2 years elapse between the time a student initially enrolls in graduate school and the date of completion of the doctoral program. In projecting entrants to the postdoctoral pool, two alternatives have been considered: (a) the fraction of graduates opting for postdoctoral training in universities will remain at the current level (0.56); or (b) this fraction will increase to 0.63 by 1987. The results of these projections are displayed in Figure 3.4. It should be noted that although first-year enrollments dropped significantly between fall 1975 and fall 1976, the number of doctoral awards 6 years later has continued to increase through FY 1982. Nevertheless, in the next 5 years or so we anticipate a significant reduction in Ph.D. production from 3,951 (FY 1982) to approximately

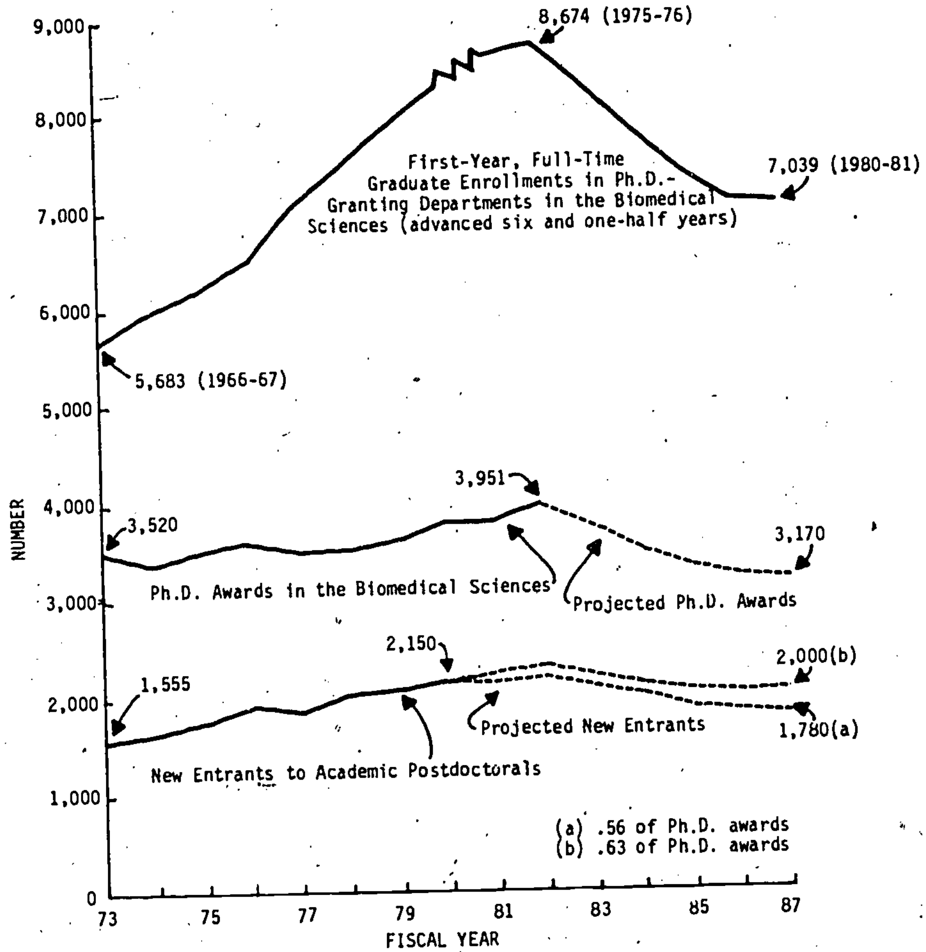

FIGURE 3.4 First-year graduate enrollments in the biomedical sciences, projected Ph.D. awards, and new entrants to academic postdoctorals, 1973-87. See Appendix Tables B2 and B3.

3,200 biomedical scientists. It is also projected that the number of new entrants to the postdoctoral population in academia will decline from 2,150 scientists (FY 1980) to somewhere between 1,790 and 2,040 individuals--depending on the proportion of Ph.D. recipients opting to take academic postdoctorals.

Some caveats are in order with regard to these projections. Whether or not a 20 percent decline in Ph.D. awards occurs will depend on factors such as the availability of financial support for graduate study, the average time it takes students to complete work for their doctorates, and other factors affecting the "completion rate" for first-year graduate students in the biomedical sciences. If past

trends continue and a decreasing fraction of the graduate students currently enrolled complete work for the Ph.D., the decline in doctoral awards may be greater than projected. On the other hand, even if the number of postdoctoral entrants is greatly reduced, the total size of the postdoctoral population may not decrease if a substantial portion stays in this setting longer.

CAREER OUTCOMES OF FORMER NIH PREDOCTORAL TRAINEES AND FELLOWS

The Committee has undertaken a study to examine the career outcomes of biomedical scientists who had received NIH predoctoral training grant or fellowship support in the past 15 years. The primary intent of the study is to "identify the kinds of research positions available to and held by individuals completing [NIH training] programs" (Section 473.b.3 of the National Research Service Awards Act of 1974) and to compare the findings with the career outcomes of other biomedical science students who had not received NIH predoctoral training grant or fellowship support. Results of this comparison are summarized here and will be presented in detail in a separate report. (An analogous study of former NIH postdoctoral trainees and fellows is planned.)

The analyses undertaken in this study focus on the early career outcomes of more than 32,000 individuals receiving at least 9 months of predoctoral (pre-Ph.D.) training grant or fellowship support from the NIH during FY 1967-80. Five general factors were considered:

1. attainment of the research doctorate
2. postdoctoral research training experience
3. early career employment
4. demonstrated interest and success in obtaining federal support for research
5. record of publication.

Comparisons were made with two other groups of biomedical science Ph.D. recipients. Group I includes biomedical science Ph.D.s who had not received at least 9 months of NIH predoctoral training grant or fellowship support but who had been in programs that had some NIH predoctoral training grant funding. Group II includes biomedical science Ph.D.s who had been in programs that had no NIH predoctoral training grant funding. The distinction between the two comparison groups is important. Individuals in Group I, while not recipients of NIH predoctoral stipends, should have benefited from having been graduate students in programs that had NIH training grant support since those grants are made on the basis of program quality.

Summarized below are highlights of the comparisons and key findings:

- Since 1972 the number of NIH predoctoral awards made each year has declined 40 percent, and the number of new awards

to individuals dropped by more than 50 percent--during a period when total Ph.D. degrees granted annually in the biomedical sciences was relatively stable.

- The median length of time an individual received NIH predoctoral support declined from 34 to 24 months.

- Nearly 70 percent of the NIH predoctorals have earned their Ph.D. degrees, compared with an estimated overall completion rate for graduate students in the biomedical sciences of less than 60 percent.

- Individuals receiving training grant or fellowship support for longer periods were significantly more likely to complete their doctoral training.

- NIH trainees typically earned their doctorates in shorter periods of time than did other biomedical science Ph.D.s in Groups I or II.

- As the number of NIH predoctoral training awards diminished during the FY 1972-80 period, an increasingly larger share of them went to graduate students enrolled in universities with distinguished reputations in the biomedical sciences.

- Former NIH trainees were nearly 30 percent more likely than other biomedical science Ph.D. recipients to pursue postdoctoral research training, and 40 percent more likely to obtain NIH postdoctoral training grant or fellowship support.

- In terms of their employment situations, former NIH predoctoral trainees did not differ markedly from biomedical scientists in comparison Group I. Both were more likely than persons in Group II to obtain faculty appointments in major research institutions and to be involved in research-related activities.

- Former NIH predoctoral trainees have been 1-1/2 times more likely than other biomedical Ph.D.s to apply for an NIH research grant, and almost twice as likely to obtain one. They received appreciably higher priority scores on their research grant applications than did individuals in either comparison Group I or Group II.

- NIH trainees had greater publication activity during the 1970-80 period than individuals in either Groups I or II. The NIH trainees had more publications per individual and a higher percentage with at least one article published than did members of the comparison groups.

In interpreting these differences in performance between the comparison groups and former NIH awardees, one must keep in mind that NIH trainees and fellows have been selected on the basis of criteria believed to reflect their abilities and interests in biomedical research. Consequently, NIH predoctorals should a priori have stronger records of achievements. The selection and support of these individuals is the true purpose of the program. The relative contributions of the selection process and the research training they received cannot be ascertained from this analysis. Nevertheless, the findings consistently indicate that former NIH predoctorals have been successful in obtaining the Ph.D. degree and developing careers as independent investigators in biomedical research. Although the observed differences among groups are not startling, the NIH trainees and fellows have out performed Group II on measures pertaining to all five criteria and did significantly better than Group I on measures pertaining to four of the five criteria. On this basis the Committee concludes that the NIH predoctoral training programs have most effectively facilitated the development of well-qualified biomedical research personnel.

THE MARKET OUTLOOK

Having discussed the current market situation and given consideration to the issues surrounding predoctoral and postdoctoral training in the basic biomedical sciences, we turn now to an assessment of the near-term and long-term employment outlook for scientists in this area.

Short-Term Projections of Academic Demand

Since the academic sector has been and will probably continue to be the main focal point for basic biomedical research, we have paid particular attention to the analysis of this sector. Our approach has been first to compile a data bank covering the past 20 years of enrollments, employment, and R and D funding at colleges and universities. Then we have developed a model of academic demand and used the data bank to estimate the parameters of the model. Finally, we use the model to make short-term projections of academic demand that in turn provide a quantitative basis for the Committee's recommendations.

The Model of Academic Demand for Biomedical Ph.D.s

Academic demand for bioscientists is created by both expansion of faculty size and attrition due to death, retirement, and movement from academic to nonacademic positions.

In the biomedical area, faculty size is assumed to be determined

by two principal factors, enrollments and R and D funding. Attrition in the short term is assumed to be a constant percentage of faculty size, with the appropriate percentage being estimated from the most recent data.

Our projections of faculty size are based on a model in which the faculty/student ratio (F/S) is assumed to be primarily determined by total R and D expenditures in colleges and universities. That such a relationship exists in the biomedical science fields is clearly evident in the data compiled for the 1962-80 period (Figure 3.5).

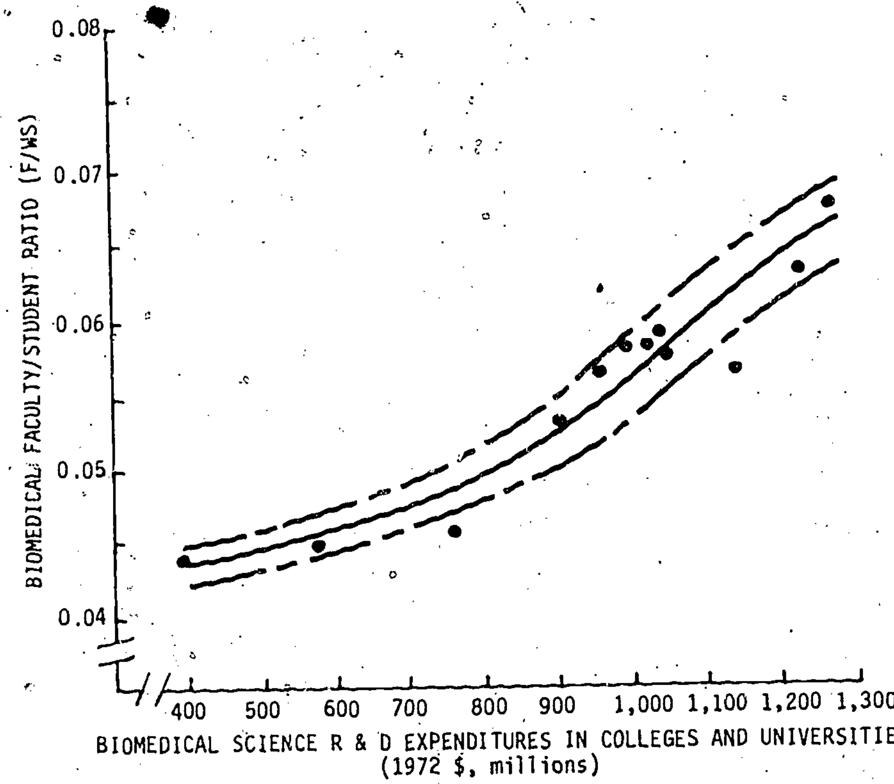

FIGURE 3.5 Biomedical science Ph.D. faculty/student ratio (F/WS) vs. biomedical science R & D expenditures in colleges and universities (D). The F/S ratio is defined as academically employed bioscience Ph.D.s relative to bioscience enrollments (WS). WS is a 4-year weighted average of enrollments, i.e., $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$ where S_t = bioscience graduate and estimated undergraduate enrollments in year t. D is defined as a 3-year weighted average of R & D expenditures; $D_t = 1/4(R_t + 2R_{t-1} + R_{t-2})$. Solid line represents a growth cruve of the form $Y = (K-C)\exp(-e^{a-bx})+C$ fitted to the data for 1962-80. Broken lines represent 95% confidence limits around the estimated curve. See Appendix Tables B6 and B9.

When the F/S ratio--defined as the number of bioscience Ph.D.s employed in colleges and universities (excluding postdoctorals) relative to a 4-year weighted average of total graduate and undergraduate enrollment in bioscience fields--is shown in relation to a 3-year weighted average of bioscience R and D expenditures (Appendix Table B9), the points exhibit a pattern suggestive of a constrained growth curve.[4] The F/S ratio grew slowly at low levels of R and D expenditures, then accelerated, and now appears to be growing less rapidly at higher expenditure levels.

For the past few years we have been using a Gompertz type growth function to model these data. The Gompertz function assumes that the percentage change in F/S decreases exponentially with R and D expenditures. It takes the following mathematical form:[5]

$$F/WS = (K-C)\exp(-e^{a-bM})+C$$

where:
- F = Ph.D.s employed by academic institutions in bioscience fields (excluding postdoctoral trainees)
- WS = 4-yr. weighted average of enrollments, i.e., $WS_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$
- M = 3-yr. weighted average of R and D expenditures
- K = asymptote: i.e., $F/S \rightarrow K$ as $M \rightarrow$ inf.
- C = scaling constant
- a, b = parameters

To use the model for projecting academic demand, it is necessary to make assumptions about the future behavior of the driving elements in the model--enrollments and R and D funding.

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[4] The exclusion of postdoctorals from the numerator of the F/S ratio is somewhat arbitrary. We recognize that postdoctorals work on research projects and derive some support from R and D funds. On the other hand, the postdoctoral appointment is primarily a training period and separate programs and sources of support are available to support that training.

[5] Fitting this function to the data from 1962-80, we get the following estimate for the parameters: K = 0.09, C = 0.0425, a = 2.603, b = 0.00214. The fitted curve is asymptotic to F/S = 0.09 and has an inflection point at M = a/b = 1217 ($, millions). Parameter estimates were derived by a least-squares regression procedure which yields an R^2 of 0.971 with 12 observations. R^2--the coefficient of determination--must lie between 0 and 1 and measures how well the assumed function fits the data, with $R^2 = 1$ representing a perfect fit. The dotted lines in Figure 3.5 represent the 95 percent confidence limits on the estimated curve.

Assumptions:

1. Total bioscience graduate and undergraduate enrollments are expected to show no growth between 1980 (the latest year for which data are available) and 1988. The upper and lower limits on the expected growth rate are +2 percent per year and -2 percent per year, respectively (see Figure 3.6).

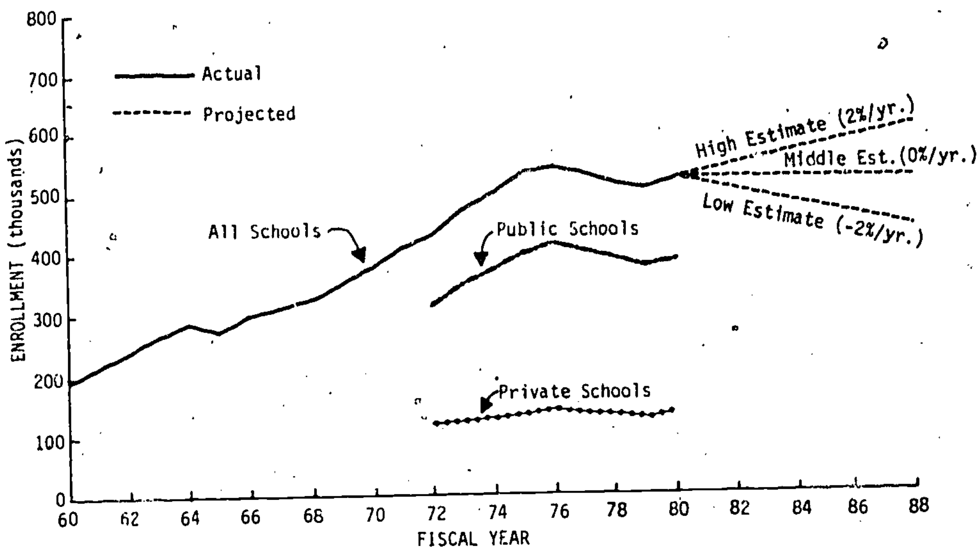

FIGURE 3.6 Total biomedical science undergraduate and graduate enrollments in colleges and universities, by control of institution, 1960-80, with projections to 1988. See Appendix Table B1.

2. Biomedical science R and D expenditures at colleges and universities are expected to grow at 2 percent per year after adjusting for price changes between 1980 and 1988. The upper and lower limits are assumed to be 4 percent per year and zero, respectively (see Figure 3.7).[6]

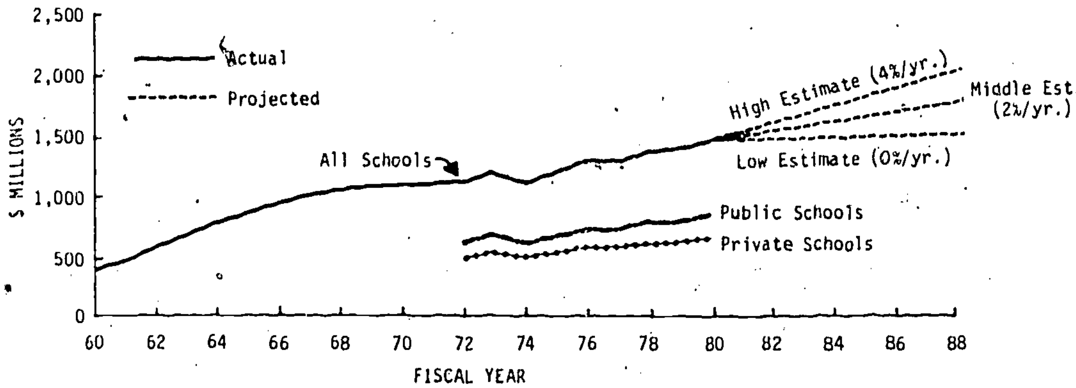

FIGURE 3.7 Biomedical science R & D expenditures in colleges and universities, by control of institution, 1960-80, with projections to 1988 (1972 $, millions). See Appendix Table B9.

Projections to 1988

Given the model and the assumptions about future patterns of R and D expenditures and enrollments, we may now make projections of academic demand for bioscience Ph.D.s. It has been the Committee's practice to make projections of academic demand for about 5 years ahead of its report--so our projections this year go through 1988 as shown in Figure 3.8 and Table 3.4.

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[6] The definition of this funding variable has been changed slightly in this report. In previous years we have defined it as life science R and D expenditures, which includes agriculture. This year we have redefined it to exclude agriculture and have called it "biomedical science" expenditures, which seems to be more directly relevant to the fields with which we are concerned.

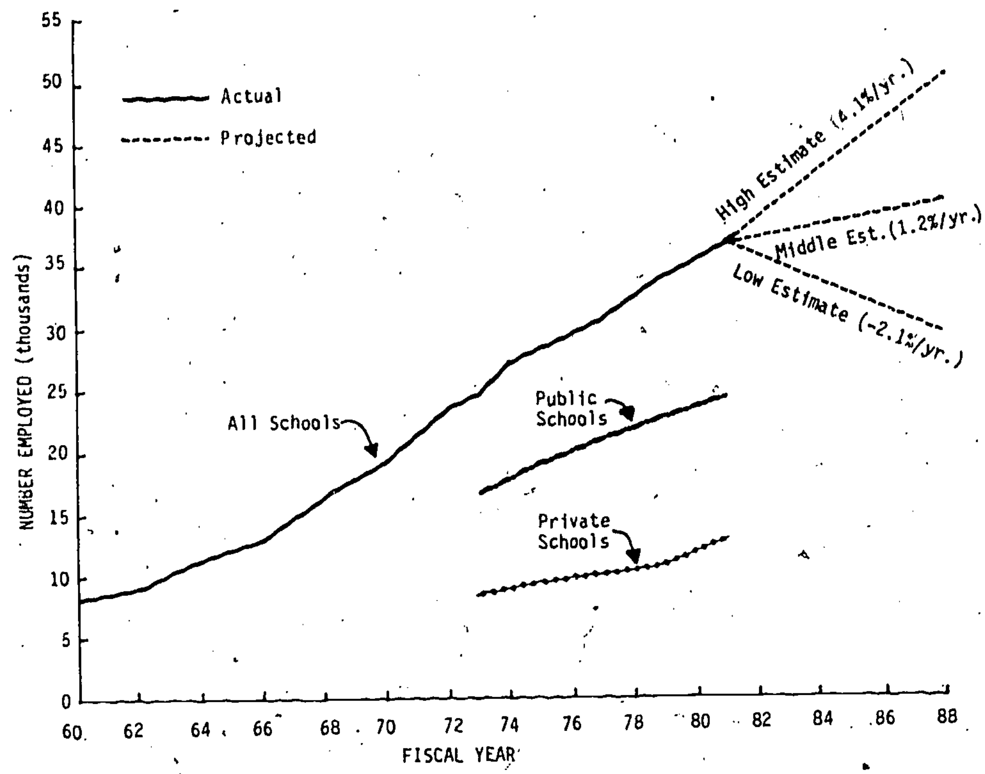

FIGURE 3.8 Ph.D.s employed in the biomedical sciences at colleg[illegible]d universities, by control of institution, 1960-81, with projections to 1988. See Appendix Ta[illegible]5.

The three assumptions about enrollment growth together with the three assumptions about R and D expenditures give nine combinations of assumptions to be used as input to the model. These are shown in Table 3.4 along with the resulting projections of academic demand due to expansion and attrition of faculty.

Under the most optimistic assumptions, bioscience R and D expenditures at academic institutions would grow by 4 percent per year through 1988 (assumption I of Table 3.4), driving the F/WS ratio to 0.080. The 95 percent confidence limits on this estimate are 0.077 and 0.083, respectively. Since the most optimistic assumptions attempt to define an upper limit on our projections, we use the upper 95 percent confidence limit on the F/WS ratio (0.083) as the most optimistic estimate.

We project academic demand by using the most optimistic estimate of enrollment growth--2 percent per year (assumption A in Table 3.4)--together with the estimated F/WS ratio of 0.083. This produces an upper estimate of faculty size of 48,500 bioscience Ph.D.s in 1988, for a faculty growth rate of 4.1 percent per year. About 1,680 positions per year would be created by faculty expansion, 420 per year

TABLE 3.4 Projected Growth in Biomedical Science Ph.D. Faculty, 1980-88, Based on Projections of Enrollment, and R and D Expenditures[a]

Assumptions about Graduate and Undergraduate Enrollments in the Biomedical Sciences and Medical and Dental Schools (516,000 students in 1980)		Assumptions about Real R and D Expenditures (in constant 1972 dollars[b]) in the Biomedical Sciences in Colleges and Universities ($1.4 billion in 1980)		
		I Will grow at 4%/yr. to $2.0 billion in 1988	II Will grow at 2%/yr. to $1.7 billion in 1988	III Will remain at current level ($1.4 billion) through 1988
A. Will grow at 2%/yr., reaching 604,000 students by 1988	Expected size of biomedical Ph.D. faculty (F) in 1988	48,500	43,800	38,300
	Annual growth rate in F from 1980 to 1988	4.1%	2.8%	1.1%
	Average annual increment due to faculty expansion	1,680	1,090	410
	Annual replacement needs due to:[c]			
	death and retirement	420	390	370
	other attrition	1,250	1,180	1,100
	Expected number of academic positions to become available for biomedical Ph.D.s	3,350	2,660	1,880
B. Will show essentially no growth from 1980-88, remaining at 516,000 students	Expected size of biomedical Ph.D. faculty (F) in 1988	42,700	38,500	33,700
	Annual growth rate in F from 1980 to 1988	2.5%	1.2%	-0.5%
	Average annual increment due to faculty expansion	940	430	-170
	Annual replacement needs due to:[c]			
	death and retirement	390	370	340
	other attrition	1,170	1,100	1,030
	Expected number of academic positions to become available annually for biomedical Ph.D.s	2,500	1,900	1,200
C. Will decline by 2%/yr. to 439,000 students by 1988	Expected size of biomedical Ph.D. faculty (F) in 1988	37,400	33,800	29,600
	Annual growth rate in F from 1980 to 1988	0.8%	-0.5%	-2.1%
	Average annual increment due to faculty expansion	290	-160	-690
	Annual replacement needs due to:[c]			
	death and retirement	360	340	320
	other attrition	1,090	1,030	970
	Expected number of academic positions to become available annually for biomedical Ph.D.s	1,740	1,210	600

[a]Faculty is defined in this table as all academically employed Ph.D.s in biomedical fields, excluding postdoctoral appointees. These projections are based on the following relationship:

$(F/WS)_t = 0.0475\ [\exp(-\exp(2.603 - 0.002138M))] + 0.0425$, where F = faculty; WS = weighted average of last 4 years of enrollments, i.e., $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = total graduate and undergraduate enrollments in biomedical fields; M = weighted average of last 3 years of biomedical science R and D expenditures in colleges and universities, i.e., $M_t = 1/4(R_t + 2R_{t-1} + R_{t-2})$. See Appendix Tables B1, B6, and B9.

[b]Deflated by the Implicit GNP Price Deflator, 1972 = 100.0. See Appendix Table B7.

[c]Based on an estimated replacement rate of 1.0% annually due to death and retirement, and 3.0% annually due to other attrition from academic positions. These estimates were derived from the National Research Council (1973-82).

would be generated by attrition due to death and retirement, and 1,250 per year would be generated by other attrition. The total number of academic positions that would become available each year under these high growth conditions is 3,350.

Under the middle or best-guess assumptions (II-B in Table 3.4), bioscience R and D expenditures at academic institutions would grow by 2 percent per year through 1988--yielding an F/WS ratio of 0.075--and bioscience enrollments would remain at 1980 levels. The best estimate of bioscience Ph.D. faculty size under these assumptions is 38,500, an increase of 430 positions or 1.2 percent per year over the 1980 level. Attrition would add another 1,470 positions to give a total annual academic demand of about 1,900.

Under the low growth assumptions (III-C in Table 3.4), bioscience R and D expenditures at academic institutions would remain at the 1980 level through 1988 and consequently the bioscience F/WS ratio would also remain at the 1980 level of 0.068. The 95 percent confidence limits on this estimate are 0.065-0.071. We use the lower limit of 0.065 to represent the most pessimistic estimate of F/WS. Bioscience enrollment would decline by 2 percent per year yielding a Ph.D. faculty size in 1988 of 29,600. That represents a drop of 690 positions per year, but attrition would add 1,290, for a net demand of 600 per year.

Estimating Postdoctoral Support Levels Under NRSA Programs

The final step in our quantitative analysis of the market is to attempt to translate the projections of academic demand into recommended levels of postdoctoral training under NRSA programs. This step requires certain additional assumptions about how the system has functioned in recent years with regard to postdoctoral training and its sources of support.

The features of the system which must be considered in addition to the projections of faculty growth are as follows:

1. contributions to academic demand generated by the need to reduce budgeted vacancies in basic science departments of medical schools
2. the number of accessions to faculty positions who have (or should have) research training
3. the appropriate length of the research training period
4. the proportion of individuals in the research training pipeline who aspire to academic careers
5. the proportion of support to the total pool of postdoctoral research trainees that should be provided by the federal government.

In the absence of complete knowledge of the system, we must make some additional assumptions about the features--first presented in the Committee's 1981 Report--in order to provide a quantitative basis for the recommendations.

Using the projections of academic demand derived in Table 3.4 and the same set of conditions specified in the 1981 Report, we calculate in Table 3.5 the range of basic biomedical science postdoctoral trainees that should be supported by NRSA programs under the specified conditions.

Line 1 of Table 3.5 is a summary of the projections of academic demand for the extreme cases and the best-guess estimate derived in Table 3.4.

Line 2 is an estimate of the demand generated by the need to reduce budgeted vacancies in basic science departments of medical schools.

Line 3 shows the total annual demand for bioscience Ph.D.s in the academic sector under each set of conditions. Total annual academic

TABLE 3.5 Estimated Number of Basic Biomedical Science Postdoctoral Trainees Needed to Meet Expected Academic Demand Through 1988 Under Various Conditions

	Projected Through 1988			Annual
	High Estimate	Middle Estimate	Low Estimate	Average 1979-81
1. Academic demand for biomedical Ph.D.s—annual average:	3,350	1,900	600	2,797
a. due to expansion of faculty	1,680	430	-690	1,404
b. due to death and retirement[a]	420	370	320	325
c. due to other attrition[b]	1,250	1,100	970	1,068
2. Demand created by unfilled positions[c]	50	50	50	
3. Total annual accessions	3,400	1,950	650	2,797
4. Total accessions with postdoctoral research training—annual average (assuming 70% of all accessions have postdoctoral research training)	2,380	1,360	450	1,715[d]
5. Size of biomedical postdoctoral pool—annual average				7,800
Size needed to meet academic demand assuming a 3-yr. training period and portion of trainees seeking academic positions is:				
a. 60%	11,900	6,800	2,250	
b. 70%	10,200	5,830	1,930	
6. Annual number of biomedical postdoctoral trainees to be supported under NRSA programs:				2,869
a. if 40% of pool is supported under NRSA	4,080-4,760	2,330-2,720	770-900	
b. if 50% of pool is supported under NRSA	5,100-5,950	2,915-3,400	965-1,125	

[a]Assumes an attrition rate due to death and retirement of 1.0% per year. In the 1990s, this rate is likely to increase substantially. See Figure 3.12 in this chapter

[b]Assumes an attrition rate due to other causes of ? year.

[c]In 1981 there were about 650 budgeted vacancies in basic science departments of medical schools. The demand for basic biomedical science faculty generated by the need to reduce the number of unfilled positions is about 50 per year through 1988.

[d]Assumes that 70% of the 1979-81 Ph.D. cohorts took a postdoctoral appointment before taking an academic position. This estimate is based on data from the National Research Council (1958-82, 1973-82).

SOURCE: Table 3.4.

demand is expected to be between 650 and 3,400 positions with a best-guess of about 1,950 positions.

Line 4 shows the number of academic positions to be filled by individuals with postdoctoral research training experience. With the help of data on the inflows and outflows from academic employment in the biosciences between 1979 and 1981 shown in Table 3.6, we estimate that 70 percent of all vacancies will be filled by former postdoctoral trainees. In the best-guess case, this number is estimated to be 1,360.

TABLE 3.6 Inflows and Outflows from Academic Employment for Biomedical Science Ph.D.s, 1979-81

I. *Average Annual Attrition from Academic Employment in the Biomedical Sciences*

1. Total biomedical Ph.D.s employed in academia in 1979: 33,687

2. Leaving academic employment between 1979 and 1981 in the biomedical sciences to:

	N	% of Academic Employment
a. nonacademic sectors	819	2.4
b. postdoctoral appointments	138	0.4
c. death and retirement	325	1.0
d. unemployed	111	0.3
e. total attrition	1,393	4.1

II. *Average Annual Accessions to Academic Employment in the Biomedical Sciences*

1. Total biomedical Ph.D.s employed in academia in 1981: 36,497

2. Entering academic employment between 1979 and 1981 in the biomedical sciences from:

	N	% of Total Accessions
a. nonacademic sectors	531	19.0
b. postdoctoral appointments	1,299	46.4
c. other fields[a]	169	6.0
d. unemployed	200	7.2
e. Ph.D. recipients 1979-81[b]	598	21.4
f. total annual accessions	2,797	100.0

III. *Balancing:* 1979 academic employment − attrition + accessions = 1981 academic employment

$$33{,}687 - 2(1{,}393) + 2(2{,}797) = 36{,}495^{c}$$

[a]These individuals were all academically employed in 1979 and 1981. The number shown represents the estimated *net* inflow to biomedical fields from other fields.
[b]It is estimated that 70% of these new Ph.D. cohorts took a postdoctoral appointment before taking an academic position.
[c]Does not agree with line II.1 because of rounding.

SOURCE: National Research Council (1973-82).

Line 5 indicates the size of the biomedical postdoctoral pool required to supply the necessary number of individuals with postdoctoral training under certain assumptions about the length of the postdoctoral training period and the proportion of the pool seeking academic employment. Currently, bioscience Ph.D.s are typically spending about 3 years in postdoctoral appointments, up from 2 years in the early 1970s. As stated earlier in this chapter, we don't know whether this lengthening of postdoctoral training is due to difficulties in finding more permanent employment, the complexity of the training curriculum, or other reasons. We intend to examine this important issue in more detail.

If the appropriate length of postdoctoral training is assumed to be 3 years, then the pool size needed to produce 1,360 trained scientists each year is 3 times 1,360 or 4,080. If 70 percent of the trainees seek academic appointments after completing their training, then the necessary pool size must be 6,800.

Line 6 shows the estimated number of biomedical science postdoctoral trainees that should be supported annually by NRSA programs under different assumptions about the proportion of total support provided by that source. The resulting range is between 700 under the lowest set of assumptions, and 5,950 under the highest set. The best-guess assumptions yield a range of 2,330-3,400 postdoctoral trainees.

Demand Outside the Academic Sector

For most of the 1970s, employment of biomedical science Ph.D.s in the nonacademic sector has been growing faster than within the academic sector. This trend appears to have accelerated in the last few years. The industrial sector is the second largest employer of biomedical scientists next to academia, employing almost 15 percent of the 69,000 biomedical Ph.D.s in the labor force. The growth rate in the industrial sector has been 8 percent per year since 1973 versus 5 percent per year in the academic sector. Of course, chemical and drug manufacturers employ most of the biomedical Ph.D.s within the business sector. But employment in the new biotechnology industry appears to be growing quite rapidly. As shown in the last line of Table 3.7, the number of biomedical science Ph.D.s employed in the nonclassifiable group of companies has been growing by 25 percent per year since 1973. Many of these are biotechnology firms that are so new or so small that their Standard Industrial Classification code could not be determined. But close examination of this group reveals that many are indeed recently formed firms engaged in biotechnology R and D.

The biomedical field in general, and the new biotechnology in particular, are currently the subjects of intense scrutiny by government, academia, and business groups as these fast-moving fields appear on the verge of producing important practical developments. Just in the past 5 years, a whole industry of some 200-300 firms has sprung up around the belief that recently developed knowledge concerning the manipulation of genes can be commercialized successfully. This proposition has yet to be proven on any large scale, but

TABLE 3.7 Ph.D.s Employed by Business and Industry in the Biomedical Sciences, 1973-81

	Fiscal Year					Annual Growth Rate	Annual Growth Rate	Average Annual Change
	1973	1975	1977	1979	1981	1973-81	1979-81	1973-81
TOTAL BUSINESS AND INDUSTRY	5,285	6,645	6,918	8,461	9,957	8.2%	8.5%	584
Agriculture, Forestry & Fish	76	67	42	66	50	-5.1%	-13.0%	-3
Mining	0	0	5	75	45		22.5%	6
Construction	6	7	27	64	32	23.3%	-29.3%	3
Manufacturing	4,408	5,460	5,714	6,149	7,032	6.0%	6.9%	328
Chemical and drugs	2,814	3,695	3,988	4,105	4,739	6.7%	7.4%	241
Petroleum refining	138	129	94	255	207	5.2%	-9.9%	9
Medical instruments	182	267	303	295	429	11.3%	20.6%	31
Other	1,274	1,369	1,329	1,494	1,657	3.3%	5.3%	48
Transport., Communication, Elec., Gas & San. Services	39	69	71	159	114	14.3%	-15.3%	9
Wholesale & Retail Trade	37	110	61	70	21	-6.8%	-45.2%	-2
Chemical and drugs	5	31	14	15	0	–	..	-1
Other	32	79	47	55	21	-5.1%	-38.2%	-1
Finance, Insur. & Real Estate	52	50	25	36	122	11.2%	84 1%	9
Services	388	413	389	534	814	9.7%	23.5%	53
Medical	169	120	113	283	179	0.7%	-20.5%	1
Other	219	293	276	251	635	14.2%	59.1%	52
Biotechnology[a]	n/a	n/a	n/a	153	262	n/a	30.9%	55 (1979-81)
Nonclassifiable Companies	279	469	584	1,155	1,465	23.0%	12.6%	148

[a] These are biomedical science Ph.D.s employed by firms that could be identified as being in the biotechnology industry according to available directories for the industry. The numbers shown probably understate the true numbers employed by biotechnology firms since the directories are not all-inclusive.

SOURCE: National Research Council (1973-82).

many industrial firms are betting huge sums that commercially profitable products will emerge.

In this highly technical and competitive race, several firms have moved to insure themselves of quick access to the latest developments by investing in joint ventures with academic institutions. Hoechst AG, a German pharmaceutical house, has agreed to fund a new department of molecular biology at Massachusetts General Hospital (affiliated with Harvard Medical School) at a cost of $70 million or more over the next 10 years. Also at Harvard, a new genetics department will be supported by a $6 million grant from E.I. du Pont de Nemours & Co. Monsanto has committed $23.5 million over 5 years to Washington University in St. Louis for research on proteins and peptides, and another $4 million to Rockefeller University for research on the structure and regulation of plant genes in photosynthesis.

Even some firms not involved with biomedical research are being attracted by the potential payoff to biotechnology. Cornell University recently announced the establishment of a new biotechnology institute with support from Union Carbide, Eastman Kodak, and Corning Glass (Walsh, 1983). Each firm has pledged up to $2.5 million annually for the next 6 years.

In addition to the industry-university relationships, many industrial firms are entering into joint ventures with other firms. In most cases, a large firm provides financial support to a smaller one in return for technical expertise. Investments by Standard Oil in Cetus, Texaco in Applied Molecular Genetics, and Fluor in Genentech are examples.

Thus, there is ample evidence that significant funds are being invested in various aspects of biomedical research by industrial firms both here and abroad. The main point of concern in this report is whether or not an adequate supply of properly trained biomedical scientists will be available to meet the demand expected to be generated outside the academic sector. It seems clear that while industry may provide an increasing share of employment opportunities for biomedical scientists, the universities will still be counted on to provide most of the training.

Survey of Biotechnology Firms

To learn more about the impact of the new biotechnology on the labor market for biomedical scientists, this Committee and the Congressional Office of Technology Assessment collaborated on a survey of the biotechnology industry. Some 265 firms who could be identified as being engaged in some aspect of biotechnology using recently developed techniques were sent a questionnaire (see Appendix E) in February 1983. Usable responses were received from 138 firms for a response rate of 52 percent. Questions were asked about the firm's biotechnology applications, the kinds of specialists being sought, and immediate plans for hiring.

Growth of the Industry

If there is any doubt that this is a very young industry, it should be dispelled by the data in Figure 3.9. Almost 80 percent of the firms initiated research and development activities related to the new biotechnology since 1978. There was continual growth in the

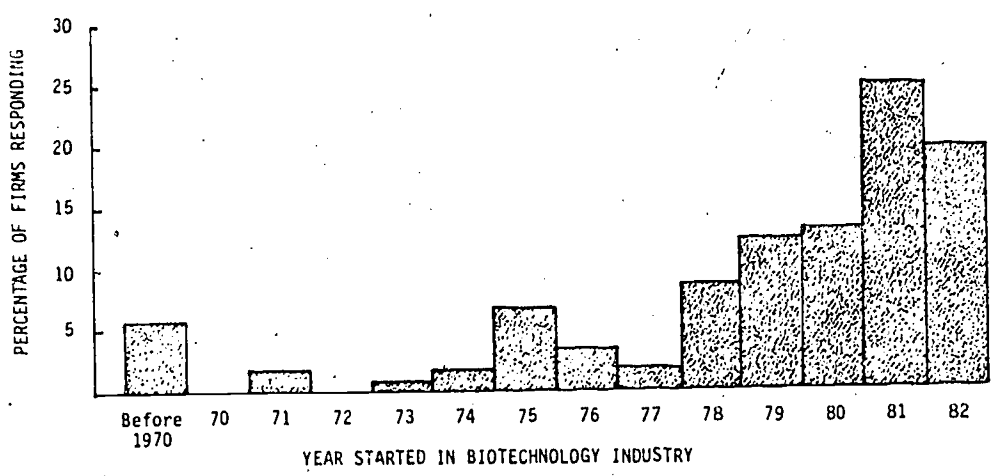

FIGURE 3.9 Percentage distribution of the year of firms' initiation of operations in biotechnology industry. See Appendix Table B15.

number of respondent firms starting operations from 1977 through 1981. The number of start-ups declined somewhat in 1982, which might be due partly to the recession and partly to the consolidation and concentration that usually occurs after the rapid emergence of many small firms.

The biotechnology industry is so new that it is quite difficult to find good data about the total number of firms operating in it and the total number of scientists employed. Several directories exist which provide lists of biotechnology firms, but there are large variations among them. Until further investigation can be made of the validity of these directories, we cannot make an accurate estimate of the total employment in the industry.

However, our survey results can provide some information on the number of scientists per firm and the specialties in which they are employed.

The majority of firms responding to our survey employed less than 10 biomedical science Ph.D.s. But there were a few who reported a substantial number of Ph.D.s--the maximum was over 90. The percentage distribution of the number of biomedical Ph.D.s per firm is presented in Figure 3.10. On average, the number of biomedical Ph.D.s per firm reported by the respondents was almost 12.

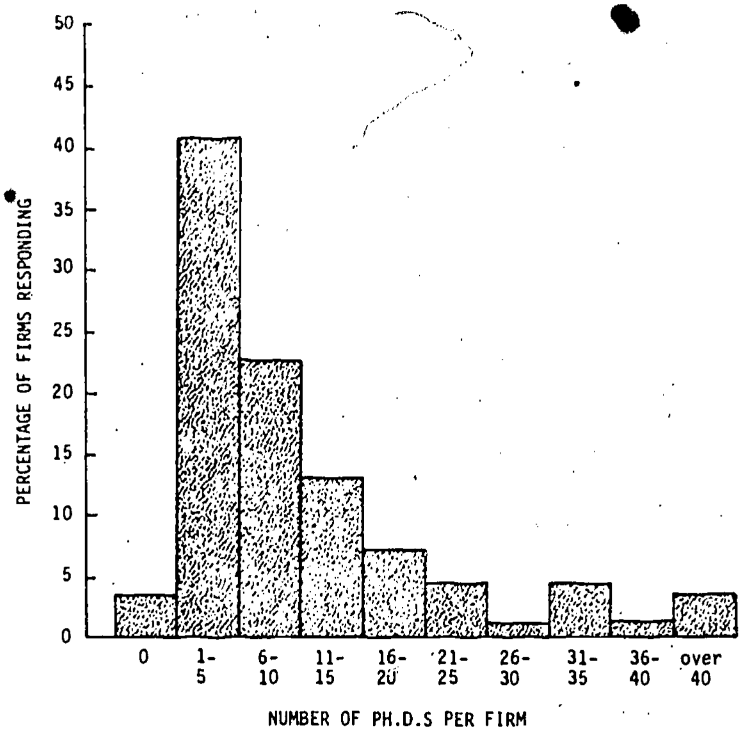

FIGURE 3.10 Distribution of the number of biomedical Ph.D.s per firm in the biotechnology industry. See Appendix Table B16.

Shortages of Specialists

Almost one-third of the respondents said they had experienced shortages of Ph.D.s in one or more specialties. Three specialties were most often cited as having shortages--bioprocess engineering, recombinant DNA/molecular genetics, and gene synthesis. Comments from the respondents reveal how they feel about current and anticipated personnel shortages. Some examples are as follows:

> "At the present time, we perceive that there is a definite shortage of well-trained bioprocess engineers and plant molecular biologists who have worked with microorganisms desirable for use in industrial fermentation such as Bacillus, Streptococcus, and even, to some extent, Yeast."
>
> A medium size R and D firm involved in animal and plant agriculture, and human vaccine applications.

> "Major shortages will exist in fermentation bioengineering in the next 2-5 years."
>
> A large established manufacturer with a small R and D group involved in human diagnostics.

> "People with strong background in recombinant technology and business, or recombinant technology and law (good patent people) are very rare at the moment."
>
> An average size R and D firm involved in pharmaceuticals and human diagnostic applications.

> "We have been successful in hiring the people we need. Hence we do not feel a shortage of candidates. Most of the projected hiring will be from outside our company--new graduates and some experienced people."
>
> A large, established chemical manufacturer.

> ". . . we anticipate that major expansion will occur in several areas as the needs of the company change:
> (a) hybridoma/monoclonal antibody technology applicable to the diagnostics market,
> (b) microbial production (fermentation) technology (e.g., industrial microbiology, bioprocess engineering,) and associated areas relevant to product quality assurance (e.g., pharmacology, toxicology)."
>
> A relatively large biotechnology firm engaged in fine chemicals, pharmaceuticals, human diagnostics, and agricultural applications.

"Personnel shortages at this point are due more to a lack of applicable experience than they are to academic training. The one specialty where there are shortages both academically and experientially is Biochemical Engineering. Furthermore, as biotechnology firms become more fully integrated, there will be an increased need for skilled technical support people; particularly in process development and manufacturing. This points out a clear need to continue our efforts toward improving university understanding of, and articulation with, developing biotechnology firms throughout the United States."

A large biotechnology firm with interests in fine chemicals and pharmaceutical applications.

Recombinant DNA/molecular genetics is currently the dominant specialty in the industry--more than 22 percent of all Ph.D.s are employed in this category (Table 3.8). General biochemistry, containing almost 12 percent of the Ph.D.s, is the second largest.

TABLE 3.8 Biomedical Ph.D.s Employed by Biotechnology Firms Responding to Survey

Employment Specialties (listed in order of number of Ph.D.s employed)	Ph.D.s Employed by 138 Responding Firms		Increase Expected in 18 Months	Shortages Indicated by Respondents[a]	
	N	%	%	N	%
1. Recombinant DNA/Molecular Genetics	303	22.6	52.1	13	12.3
2. Biochemistry, General	158	11.8	16.5	4	3.8
3. Hybridomas/Monoclonal Antibodies	104	7.8	39.4	8	7.5
4. Microbiology, General	94	7.0	22.3	3	2.8
5. Enzymology/Immobilized Systems	91	6.8	26.4	7	6.6
6. Bioprocess Engineering	80	6.0	56.3	15	14.2
7. Industrial Microbiology	74	5.5	58.1	7	6.6
8. Other Biotechnology Specialties	63	4.7	20.6	6	4.7
9. Cell Culture	53	4.0	45.3	6	5.7
10. Analytic Biochemistry	50	3.7	26.0	5	4.7
11. Pharmacology	46	3.4	28.3	1	0.9
12. Plant Molecular Biology	40	3.0	75.0	7	6.6
13. Toxicology	35	2.6	14.3	2	1.9
14. Cell Biology/Physiology	35	2.6	28.6	4	3.8
15. Gene Synthesis	33	2.5	75.8	11	10.4
16. Classical Genetics	28	2.1	25.0	1	0.9
17. Plant Biology/Physiology	27	2.0	66.7	2	1.9
18. Cell Fusion	12	0.9	41.7	3	2.8
19. Physiology	12	0.9	0.0	0	0.0
20. Animal Reproduction/Embryotransplantation	2	0.1	200.0	2	1.9
TOTAL	1,340	100.0	39.0	107	100.0

[a]Each respondent could indicate multiple shortage categories. Therefore, the number of responses in this column total more than the 50 firms reporting a shortage.

SOURCE: Committee/OTA Survey of Biotechnology Firms (1983).

Substantial growth in the employment of biomedical scientists by these firms can be expected for the next year or two. The respondents expect to increase their employment of biomedical Ph.D.s by 39 percent over the next 18 months. If the employers' plans hold up--they are often overly optimistic--some specialties will show dramatic increases in demand. The number of specialists in gene synthesis employed in the industry can be expected to increase by 76 percent. Employment in the specialties of plant biology, industrial microbiology, and bioprocess engineering may also show large increases.

Long-Term Considerations

As already discussed in this chapter, increasing numbers of recent biomedical science graduates have found employment opportunities in research outside the academic sector. Should this trend continue--and the results of the survey of biotechnology firms indicate that it will--it should have a significant impact on the future demand for biomedical research personnel.

Also, the number of scientists who are expected to reach retirement age will steadily rise during the next 20 years--thereby creating an additional demand for investigators. Furthermore, if one assumes that the level of predoctoral support in FY 1985-87 (the period for which the Committee is making recommendations) affects primarily the stock of students entering graduate school during this period, then the major impact of any changes in this stock on the labor force are not likely to be realized until 1994-96, when these students have completed 6 years of graduate education and another 3 years of postdoctoral research training.

In view of the above considerations the Committee believes that, in arriving at its recommendations for this report, a comprehensive approach that takes into account both nonacademic demand and long-term requirements is needed. Such an approach, however, must be interpreted with circumspection--due to the great uncertainties involved in making long-range projections and to the dearth of information about the key determinants of demand outside the academic sector.

Some data have already been presented on recent expansion in employment in the nonacademic sectors. These trends are illustrated in Figure 3.11. As reported in the previous section, preliminary findings from a survey of biotechnology firms suggest that further increases may be anticipated for the next several years. While longer range projections of expansion in the nonacademic sectors are considerably more uncertain, the Committee finds no reason to expect the growth trends of the past decade to be curtailed in the future. Should the total numbers employed in the nonacademic sectors continue to increase at 6 percent per year, for example, the net result would be an accretion of more then 18,000 positions over the next 10 years and more than 52,000 over the next 20 years. Such increases, should they occur, would obviously have a major impact on the overall requirements for biomedical research personnel.

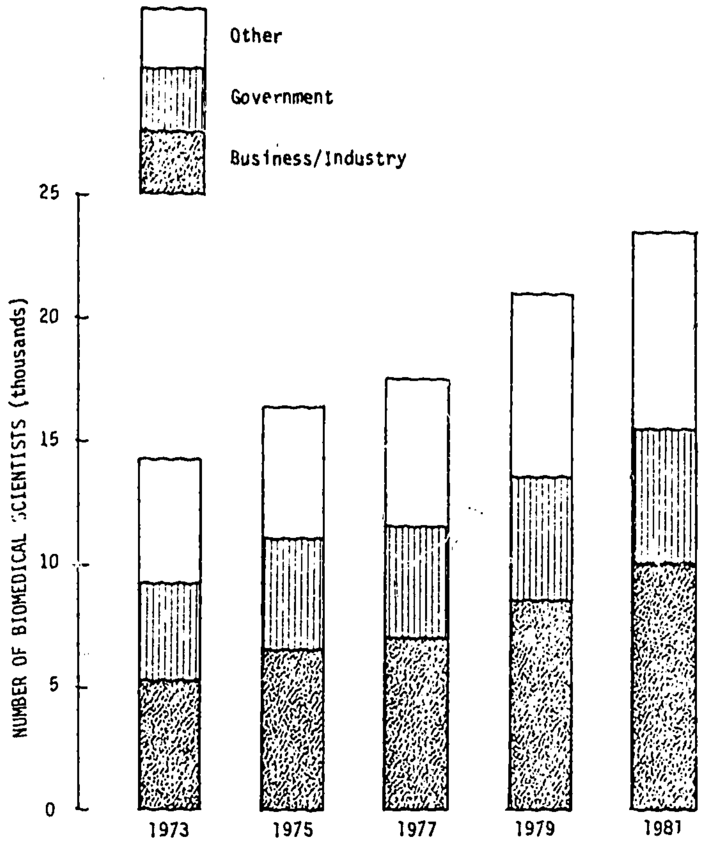

FIGURE 3.11 Number of Ph.D. biomedical scientists employed outside the academic sector (excluding postdoctoral appointments), 1973-81. See Appendix Table B5.

Far more predictable are projections of the numbers of job openings created as a result of deaths and retirements. The loss through attrition may be estimated from the age distribution of the 1981 biomedical science labor force--using the number of individuals who will reach the age of 65 by a specified year. Illustrated in Figure 3.12 are estimates of annual attrition from the academic and nonacademic segments of the labor force during the 1983-2001 period. As shown in the figure, the number of employment positions becoming available each year as a result of attrition is expected to be more than triple in the academic sector over the next 20 years and more than double in the nonacademic sectors. By the year 2001 a total of more than 13,200 replacements in the Ph.D. labor force in the biomedical sciences are expected--with 8,200 of these in universities and colleges. It should be pointed out, however, that if the average age of retirement should become significantly older (as a consequence

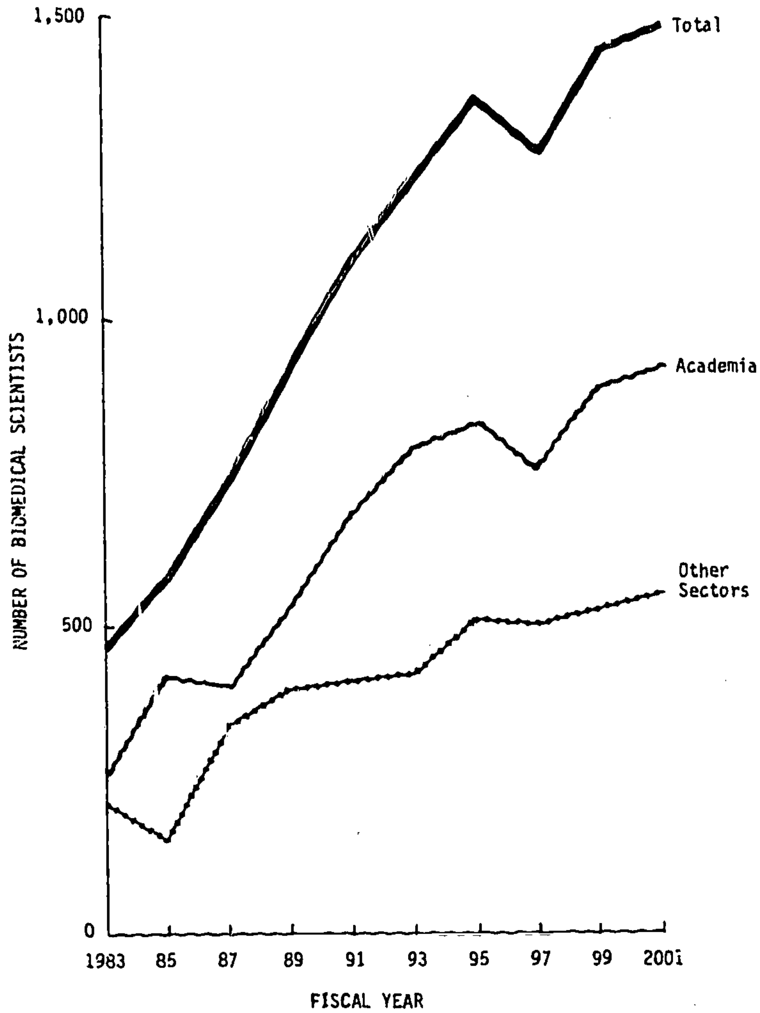

FIGURE 3.12 Annual number of biomedical scientists in the FY 1981 Ph.D. labor force expected to reach the age of 65 during the FY 1983-2001 period. See Appendix Table B18.

of legislative change), this would have the effect of delaying the impact of the expected increases in replacements. Nevertheless, even if the average retirement age were to increase by as much as 5 years, the annual loss from the biomedical labor force in the year 2001 would still be more than 2-1/2 times the size of the present attrition.

What are the implications of these projections for future requirements for research personnel in the biomedical sciences? If Ph.D. production were to remain at its current level of approximately 4,000 graduates each year, then the supply may be adequate to meet

what is perceived to be a relatively strong demand for talented young investigators. However, recent trends in first-year graduate enrollments in the biomedical sciences (see Figure 3.4 presented earlier in this chapter) suggest that the supply of new Ph.D. recipients may decline by as much as 20 percent over the next 5 years. This decline can be attributed, in part, to demographic changes. The size of the college-age population began to fall off in the mid-1970s, and this trend is expected to continue until the late 1990s. Consequently, there is an increased likelihood that further declines in Ph.D. output in the biomedical sciences will occur during the late 1980s, and throughout the 1990s. Should such declines occur, shortages of biomedical research personnel could develop in the next decade. To avoid such an occurrence, we believe that it is in the national interest for the federal government to maintain its support of graduate training for promising young investigators in the biomedical disciplines.

4. Behavioral Sciences

Clinical behavioral science Ph.D.s are faring better than the nonclinical ones, apparently because of the additional opportunity for self-employment as practitioners. But it is the nonclinical component of the behavioral sciences that conducts most of the research in the field and is the principal concern of this report. The nonclinical component is employed primarily in academic institutions where only modest growth in Ph.D. employment is expected for the next few years. But attrition from the labor force will begin to increase substantially in the 1990s. On the supply side, nonclinical enrollments and Ph.D. production are falling and there is no large reservoir of postdoctoral trainees to call on as there is in the biomedical fields.

INTRODUCTION AND OVERVIEW

In 1976 this Committee found some disturbing trends developing in the labor market for behavioral scientists. Both the National Science Foundation and the Bureau of Labor Statistics had just published studies warning of a potential oversupply of Ph.D.-level scientists in many fields by 1985 (NSF, 1975b; and U.S. Department of Labor, 1975). The life sciences and the social sciences (including psychology) were among the fields cited.

The Committee's own analyses seemed to confirm those findings. Although college and university enrollments in the behavioral fields were still growing in the early 1970s, it was evident from demographic considerations that they would soon grow at a slower rate as the "baby boom" bulge completed its passage through the college-age years. That was expected to happen in the early 1980s. After that, enrollments would begin to decline in most fields for the next 10 or 15 years. Since growing enrollments throughout the 1960s had spurred expansion of employment in the academic sector, a reversal of the enrollment

trend could be expected to cause a corresponding decline in academic demand. Those fields for which the academic sector is the primary employment market would be likely to feel the impact of this shrinking market quite heavily. In the behavioral sciences, about 65 percent of the Ph.D. labor force was academically employed in 1972. So graduates in this field obviously were quite dependent on academic employment and on enrollment trends.

Furthermore, by 1975 Ph.D. production in the behavioral fields had reached a level of more than 3,900 per year, twice the number produced in 1968. At that rate of increase in supply, the labor force of behavioral science Ph.D.s was sure to grow rapidly over the next few years. The Committee was concerned that this growth, combined with the expected slowdown in demand, would eventually produce an oversupply of behavioral scientists. Yet it also recognized the need for scientists trained to study important behavioral issues in relation to health problems. The Committee's solution was to call for redirection of the federal training programs from one which emphasized predoctoral training to one which emphasized postdoctoral training. The recommended ratio of federally-supported training positions in the behavioral sciences was ultimately to be 30 percent predoctoral and 70 percent postdoctoral. This was to be achieved gradually by shifting resources within the overall program which was to be maintained at a constant level. Here is the Committee's original statement from its 1976 Report (NRC, 1975-81):

> The Committee recognizes the need for continued federal support of training of the behavioral scientists who are conducting research relevant to the health needs of the country. Current trends in behavioral science research, however, suggest that a significant reorientation of emphasis in the federally supported research training effort is desirable at this time. Scientific advances in these fields have vastly increased the complexity of research methods and imposed requirements for more intensive training. While the number of Ph.D.-level individuals currently being trained in the behavioral sciences appears to meet market demands in the conventional disciplines, there is a growing need for more specialized behavioral science research training to deal with these increasingly complex research questions in the area of behavior and health. The Committee therefore recommends an orderly tapering down of predoctoral support with a concomitant emphasis on providing for research specialization through postdoctoral training, thus assuring the active application of advanced research training to meet the health needs of the country.
>
> The Committee recommends that the current apportionment of about 10 percent postdoctorals and 90 percent predoctorals trained in the behavioral

> sciences through this program should be modified so that ultimately 70 percent of the individuals supported by NRSA funds are postdoctoral students and 30 percent are predoctoral students. In this way the Committee believes sufficient opportunity for training in the behavioral sciences at the postdoctoral level will be assured, while an adequate number of awards for basic research training at the predoctoral level also will be maintained. However, it is recommended that this change should be implemented gradually and at essentially a constant level of federal funding in FY 1976, FY 1977, and FY 1978, in order to minimize the dislocations that could otherwise occur for both programs and personnel. Because of the greater cost of postdoctoral training, this shift will mean significant reduction in the number of behavioral science investigators trained with federal funds during the 3-year period; however, the change is expected to enhance the quality of both the programs and the trainees.... The Committee will monitor closely the result of this change and will discuss in future reports whether modification of this recommendation is warranted.

The Committee's recommendation was not, and still is not, readily accepted by some influential members of the behavioral science community. The American Psychological Association (APA) in particular has on several occasions objected both to the Committee's assessment of the market outlook and to its recommended shift in training support.[1]

On August 25, 1982, the APA held a symposium to discuss the role of postdoctoral training in the behavioral sciences. Several directors of postdoctoral training programs described their experiences in initiating and conducting their programs. In some cases, the programs seemed to be working well and providing valuable opportunities for sharpening research skills--in psychotherapy and in developmental psychology, for example. But while some program directors seemed quite receptive to the notion of expanding the role of postdoctoral training, they also were uncomfortable with the idea of relinquishing any support for predoctoral trainees.

The Committee has given these developments a great deal of consideration. We have heard statements both supporting and opposing our position from participants at the public meetings we convened to discuss our reports. We have continued to monitor the system, reviewed past data and collected new data, disaggregated the data to the extent we felt it feasible, reconsidered the recommendations and the evidence on which they were based, and discussed at length with agency representatives the difficulties involved in implementing the recommendations.

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[1] Based on testimony at Committee's public meeting on June 2, 1982. See Pallak (1982).

It should be noted here that the constant level of funding for research training in the behavioral sciences recommended by the Committee has not occurred. The research training budget of ADAMHA dropped from $19.7 million in 1975 to $16.9 million in 1978 (Appendix Table D4). It rose somewhat in the interim but by 1982 it was down to $17.2 million--still below the 1975 level. Furthermore, in the last few years there has been a rather obvious shift away from traditional research fields into the more clinical fields of behavioral sciences. This has occurred both at the employment level and at the training level. Graduate enrollments and Ph.D. production in nonclinical fields are beginning to decline while those in the clinical fields continue to increase. So after carefully considering the arguments on both sides, and after reviewing the latest data and analyses presented in this chapter, the Committee has concluded that circumstances have changed enough since 1975 to warrant a revision to previous recommendations. Whereas the short-term outlook in earlier years appeared to support the Committee's earlier projections, current circumstances, longer-term considerations, and the difficulty of implementing the recommendations in a period of reduced budgets convince the Committee that some modification is now in order. The recommendations for behavioral science fields stated in Chapter 1 reflect the Committee's belief that predoctoral training should remain at the 1981 level (about 650 awards) during the mid-1980s while post-doctoral support should increase modestly from the 1981 level of about 350 awards to about 540 awards by 1987.

THE TRAINING SYSTEM IN BEHAVIORAL SCIENCE FIELDS

Training and career patterns for Ph.D. behavioral scientists differ in some important respects from those that are found in the biomedical sciences generally. The major differences arise from the fact that psychologists, who constitute the bulk of the behavioral science doctoral output, have open to them the possibility of independent practice in the broad areas of clinical and counseling psychology. Practice of this kind is regulated in the U.S. through the mechanism of licensing, with accompanying requirements as to the specific content of the training of the license holder. Doctorates in clinical and counseling psychology are usually eligible for licenses to practice provided that they have had a certain amount of supervised clinical experience and upon passing an examination. Doctorates in other fields of psychology may make themselves eligible by undertaking additional training at a postdoctoral level, either through the formal mechanisms of postdoctoral fellowships designed for the purpose or through informal arrangements in clinical settings.

Doctorates in psychology may be divided into several identifiable types. First, there are those who are trained in the nonclinical areas and are aiming at a research career similar in all essentials to the career patterns found in the biological sciences. Second, there are those who are formally trained in the clinical areas of psychology and whose career patterns show resemblances to those of physicians,

namely a pattern of research, of clinical service, or some mixture of the two. For the first group, postdoctoral training in research is an established part of normal career development--again much as is the case in the biological sciences generally. This is particularly true of those areas of nonclinical psychology that overlap directly into the biological sciences, such as in psychopharmacology, behavior genetics, neuropsychology and the like. It is less true of the non-biological nonclinical areas of psychology such as social psychology, personality and developmental psychology. Postdoctoral research training is relatively rare for doctorates in clinical and counseling psychology.

Because there is a channel for entry into a career of clinical service, the pool of research trained psychologists is subject to some drain away from research activity into service and practice. When employment in research and academic posts becomes difficult to find, the pressures to seek a license and enter a clinical service career become strong. More widespread coverage of clinical services by health insurance plans adds to the attraction of a clinical practice career. Hence, estimates of the magnitude of the pool of research scientists in the field of psychology must be moderated by recognition of the rate of shift into clinical and self-employed categories of people trained originally for research careers. As later portions of this chapter indicate, such a shift has now been under way for some time and is increasing rapidly.

Figure 4.1 provides an illustration of the "training system" in the behavioral sciences and may be helpful in describing the stages through which promising young students pass along their way to careers in research. The numerical estimates in this figure represent the average numbers of individuals each year who have followed particular career paths during the 8-year period from 1973 to 1981. Entering at the far left are 5,300 students (path A), who having earned baccalaureate degrees in psychology and other social science disciplines, decided to pursue doctoral study in the behavioral sciences. This group constitutes less than 5 percent of all individuals receiving B.A.s in the social sciences. Another 2,000 individuals enrolled in Ph.D. programs after completing their undergraduate training in fields outside the social sciences (path B). At the right in Figure 4.1 is the active Ph.D. labor force--estimated to include 52,900 behavioral scientists (excluding postdoctorals) in FY 1981.

Between 1973 and 1981 the loss from the labor force due to death and retirement (path I) has averaged only 300 individuals (approximately 0.5 percent) annually. During this same period the total number of Ph.D.s entering the behavioral science work force for the first time (paths D, G, and H) is estimated to have been 4,200 scientists. The majority of these individuals have entered directly after completing their doctoral training (path D), while the number finishing postdoctoral training (path H) has been quite small--especially in contrast with the biomedical sciences. As a result of the sizeable stream of new Ph.D.s and the very modest attrition out of the work force, the total pool of doctoral scientists employed in the behavioral fields has been growing at a rate of 3,900 individuals a year. Much of this expansion has occurred outside the academic sector and involved employment in the clinical specialties.

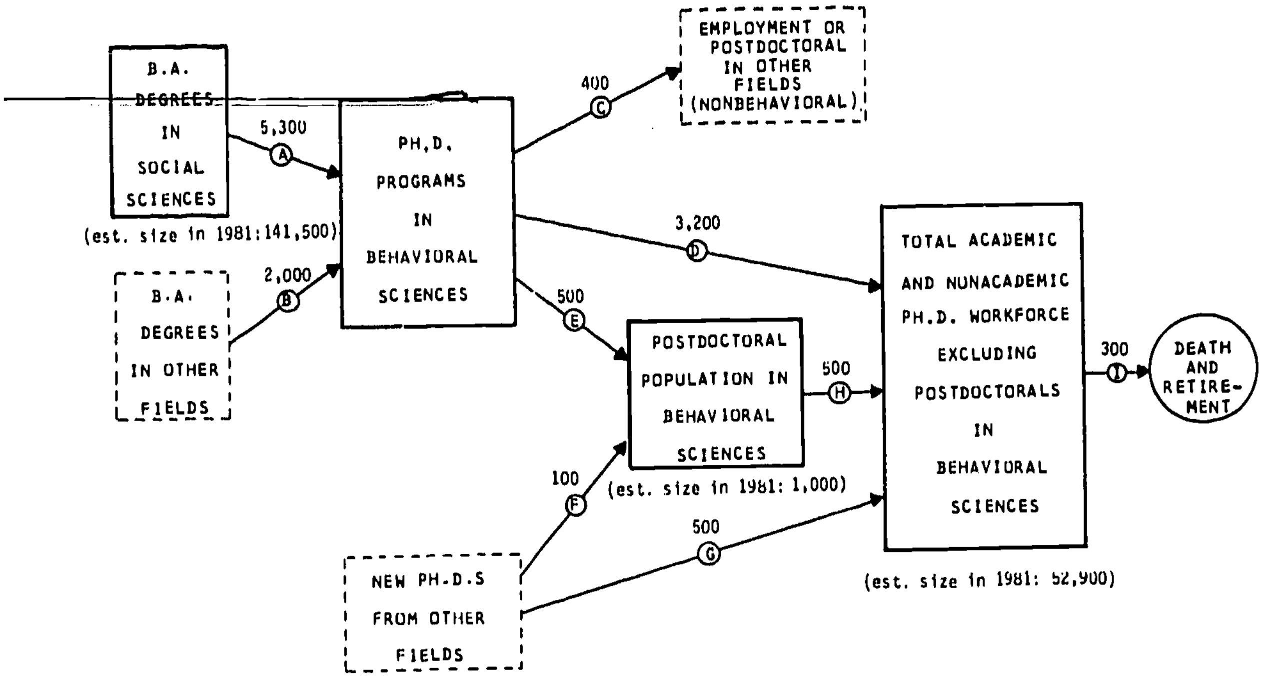

FIGURE 4.1 Doctoral training system in the behavioral sciences. Estimates represent the average annual number of individuals following particular pathways during the 1973-81 period. No estimates have been made for immigration, emigration, or re-entry into the labor force.

A more detailed analysis of the training system in the behavioral sciences is shown in Figure 4.2. In this figure the behavioral sciences are divided into clinical and nonclinical components.[2] Numbers for BA degrees and graduate school enrollments (used to calculate paths A and B) are not available separately and therefore are not presented in the figure.

The average number of Ph.D.s awarded over the 1973-81 period was 1,400 for the clinical areas and twice that number for the nonclinical areas. Switching to other fields has been much more prevalent for nonclinical Ph.D.s (path C), many of whom switch into the clinical fields. In addition, more Ph.D.s are entering clinical fields from other areas than are entering nonclinical fields (paths F and G).

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[2] Clinical fields are counseling and guidance, clinical psychology, and school psychology. Nonclinical fields are sociology, anthropology, and nonclinical psychology fields.

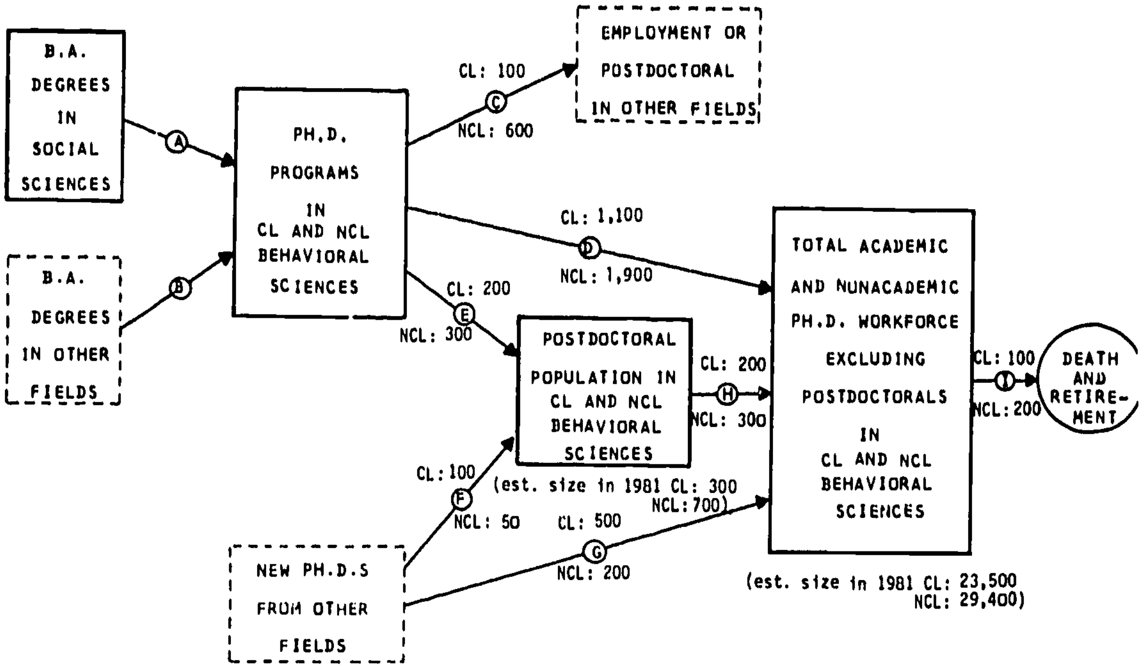


FIGURE 4.2 Doctoral training system in the clinical (CL) and nonclinical (NCL) behavioral sciences. Estimates represent the average annual number of individuals following particular pathways during the 1973-81 period. No estimates have been made for immigration, emigration, or re-entry into the labor force. Movement between clinical and nonclinical specialties within the behavioral sciences is treated as field switching in the above figure but it was not in Figure 4.1. Therefore, the sum of clinical and nonclinical scientists following path C in Figure 4.2 does not equal those taking path C in Figure 4.1. The same is true for paths D, E, F, and G.

THE MARKET OUTLOOK

The latest data on the indicators of the current state of the labor market for behavioral scientists are shown in Tables 4.1 and 4.2. The complete set of data pertaining to the behavioral sciences is presented in Appendix Tables C1-C12.

TABLE 4.1 Current Trends in Supply/Demand Indicators for Behavioral Science Ph.D.s[a]

	Fiscal Year							Growth Rate From 1975 to Latest year	Latest Annual Change	Average Annual Change from 1975 to Latest Year
	1975	1976	1977	1978	1979	1980	1981			
1. SUPPLY INDICATORS (New Entrants):										
a. Ph.D. production	3,938	4,190	4,247	4,207	4,245	4,193	4,469	2.1%	6.6%	89
b. % of Ph.D.s without specific employment prospects at graduation	13.3%	15.0%	15.6%	16.7%	15.5%	14.9%	14.6%	1.6%	−2.0%	0.2%
c. Postdoctoral appts.	739	n/a	1,038	n/a	1,144	n/a	1,016	5.4%	−5.8%[d]	46
d. B.A. degrees awarded[b]	88,877	83,521	77,627	72,348	67,555	65,283	61,435	−6.0%	−6.0%	−4,574
2. DEMAND INDICATORS:										
a. Behavioral science R and D expenditures in colleges and universities (1972 $, mil.)	$ 117.2	$ 107.6	$ 103.8	$ 103.0	$ 105.7	$ 112.6	$ 114.9	−0.3%	2.0%	$ −0.4
b. Ph.D. faculty/student ratio[c]	0.034	n/a	0.038	n/a	0.041	0.044(est.)	n/a	5.3%	7.3%	0.002
3. LABOR FORCE:[d]										
a. Total	38,781	n/a	44,351	n/a	49,355	n/a	53,917	5.6%	4.5%	2,523
b. Academic (excl: postdocs.)	23,631	n/a	25,588	n/a	26,894	n/a	28,277	3.0%	2.5%	774
c. Business	1,410	n/a	1,789	n/a	1,955	n/a	2,735	11.7%	18.3%	221
d. Government[e]	2,641	n/a	2,950	n/a	3,275	n/a	3,391	4.3%	1.8%	125
e. Hospitals/clinics	4,958	n/a	5,640	n/a	6,126	n/a	6,560	4.8%	3.5%	267
f. Nonprofit	1,164	n/a	1,496	n/a	2,156	n/a	2,112	10.4%	−1.0%	158
g. Self-employed	2,708	n/a	3,648	n/a	5,216	n/a	7,279	17.9%	18.1%	762
h. Other (incl. postdocs.)	1,880	n/a	2,474	n/a	2,983	n/a	2,845	7.1%	−2.3%	161
i. Unemployed and seeking	389	n/a	766	n/a	750	n/a	718	10.8%	−2.2%	55
4. BEHAVIORAL SCIENCE ENROLLMENTS:[b]										
a. Est. undergraduate[f]	636,000	640,000	603,000	588,000	555,000	571,000	n/a	−2.1%	2.9%	−13,000
b. Total graduate	49,036	51,796	50,981	55,769	55,771	55,773	56,394	2.4%	1.1%	1,226
c. Total undergraduate and graduate enrollment	685,000	692,000	654,000	644,000	611,000	627,000	n/a	−1.8%	2.6%	−11,600

[a] Behavioral sciences include anthropology, sociology, psychology, and speech and hearing sciences.

[b] Numbers are lower than those presented in previous reports because speech pathology/audiology has been removed from the behavioral science taxonomy. It has been determined that this field is not equivalent to the behavioral field, speech and hearing sciences.

[c] Ratio of academically employed Ph.D.s to a 4-year weighted average of total graduate and undergraduate enrollments (WS), where $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$.

[d] Since labor force data are not available for 1980, latest annual change represents average annual growth rate from 1979-81.

[e] Also includes FFRDC laboratories.

[f] Estimated by the formula $U_i = (A_{i+2}/B_{i+2})C_i$, where U_i = behavioral science undergraduate enrollment in year i; A_{i+2} = behavioral science B.A. degrees awarded in year i+2; B_{i+2} = total B.A. degrees awarded in year i+2; C_i = total undergraduate enrollment in year i.

SOURCES: NRC (1958-82, 1973-82); NSF (1973-83a, 1975-83); U.S. Department of Education (1948-83, 1959-79, 1961-82, 1973-82, 1974-82).

TABLE 4.2 Current Trends in Supply/Demand Indicators for Clinical and Nonclinical Behavioral Science Ph.D.s[a]

	Fiscal Year 1975	1976	1977	1978	1979	1980	1981	Growth Rate From 1975 to Latest Year	Latest Annual Change	Average Annual Change from 1975 to Latest Year
1. SUPPLY INDICATORS (New Entrants):										
Nonclinical fields:										
a. Ph.D. production	2,794	2,897	2,894	2,743	2,736	2,612	2,729	−0.4%	4.5%	−11
b. % of Ph.D.s without specific employment prospects at graduation	12.8%	15.0%	15.5%	16.2%	15.0%	14.9%	14.5%	2.1%	−2.7%	0.3%
c. Postdoctoral appts.	558	n/a	654	n/a	827	n/a	721	4.4%	−6.6%[b]	27
Clinical fields:										
d. Ph.D. production	1,144	1,293	1,353	1,464	1,509	1,581	1,740	7.2%	10.1%	99
e. % of Ph.D.s without specific employment prospects at graduation	14.7%	14.8%	16.0%	17.6%	16.3%	14.6%	14.8%	0.1%	1.4%	0%
f. Postdoctoral appts.	181	n/a	384	n/a	317	n/a	295	8.5%	−3.5%[b]	19
2. LABOR FORCE:[b]										
Ph.D.s employed in nonclinical behavioral fields:										
a. Total	23,908	n/a	26,760	n/a	28,150	n/a	30,168	4.0%	3.5%	1,043
b. Academic (excl. postdocs.)	18,480	n/a	20,151	n/a	21,108	n/a	22,130	3.0%	2.4%	608
c. Business	1,241	n/a	1,376	n/a	1,503	n/a	1,896	7.3%	12.3%	109
d. Government[c]	1,380	n/a	1,698	n/a	1,611	n/a	1,720	5.6%	3.3%	80
e. Hospitals/clinics	527	n/a	538	n/a	482	n/a	588	1.8%	10.4%	10
f. Nonprofit	783	n/a	820	n/a	1,037	n/a	1,067	5.3%	1.4%	47
g. Self-employed	462	n/a	501	n/a	458	n/a	1,083	15.3%	53.4%	104
h. Other (incl. postdocs.)	705	n/a	993	n/a	1,329	n/a	1,151	8.5%	−6.9%	74
i. Unemployed and seeking	330	n/a	683	n/a	622	n/a	533	8.3%	−7.4%	34
Ph.D.s employed in clinical behavioral fields:										
j. Total	14,873	n/a	17,591	n/a	21,205	n/a	23,749	8.1%	5.8%	1,479
k. Academic (excl. postdocs.)	5,151	n/a	5,437	n/a	5,786	n/a	6,147	3.0%	3.1%	166
l. Business	169	n/a	413	n/a	452	n/a	839	30.6%	36.2%	112
m. Government[c]	1,261	n/a	1,252	n/a	1,664	n/a	1,671	4.8%	0.2%	68
n. Hospitals/clinics	4,431	n/a	5,102	n/a	5,644	n/a	5,972	5.1%	2.9%	257
o. Nonprofit	381	n/a	676	n/a	1,119	n/a	1,045	18.3%	−3.4%	111
p. Self-employed	2,246	n/a	3,147	n/a	4,758	n/a	6,196	18.4%	14.1%	658
q. Other (incl. postdocs.)	1,175	n/a	1,481	n/a	1,654	n/a	1,694	6.3%	1.2%	87
r. Unemployed and seeking	59	n/a	83	n/a	128	n/a	185	21.0%	20.2%	21
3. BEHAVIORAL SCIENCE ENROLLMENTS:										
Graduate:[d]										
a. Est. nonclinical	34,196	34,871	33,717	36,084	35,479	34,864	n/a	0.4%	−1.7%	134
b. Est. clinical	14,800	16,900	17,300	19,685	20,292	20,909	n/a	7.2%	3.0%	1,222

[a]In this table, clinical behavioral fields include clinical and school psychology, counseling, and guidance; nonclinical behavioral fields include anthropology, sociology, nonclinical psychology, and speech and hearing sciences.
[b]Since labor force data are not available for 1980, latest annual change represents average annual growth rate from 1979-81.
[c]Also includes FFRDC laboratories.
[d]Numbers are lower than those presented in previous reports because speech pathology/audiology has been removed from the behavioral science taxonomy. It has been determined that this field is not equivalent to the behavioral field, speech and hearing sciences. Total graduate enrollment in clinical behavioral fields was estimated by the formula $CG_i = (CP/TP)_{i+2} E_i$, where CG_i = clinical graduate enrollment in year i; $(CP/TP)_{i+2}$ = ratio of clinical psychology Ph.D.s to total psychology Ph.D.s awarded in year i+2; E_i = psychology graduate enrollment in year i. Nonclinical graduate enrollment was obtained by subtracting clinical from total behavioral science graduate enrollment.

SOURCES: NRC (1958-82, 1973-82); NSF (1973-83a); U.S. Department of Education (1948-83, 1959-79, 1961-82, 1973-82, 1974-82).

The total labor force of Ph.D.s employed in the behavioral science fields continued to grow in 1981 at a steady rate of about 5 percent per year (Table 4.1, line 3a). Employment in clinical behavioral fields--defined as clinical and school psychology, counseling and guidance--is growing much faster than in the nonclinical fields--defined as anthropology, sociology, nonclinical psychology, and speech and hearing sciences. Growth in academic employment of both clinical and nonclinical behavioral science Ph.D.s continues at a steady pace of about 3 percent per year (Table 4.2 and Figure 4.3). Some other highlights of these data follow.

Enrollments

Total behavioral science graduate and estimated undergraduate enrollment have continued a decline that started in 1973. Most of the decline has come at the undergraduate level. Graduate behavioral enrollments in both the clinical and nonclinical fields have increased since 1977--up by a strong 6.5 percent per year in the clinical fields and by a more moderate 1.8 percent per year in the nonclinical fields, although the latter declined somewhat in 1980 and 1981 and appears to be headed down.

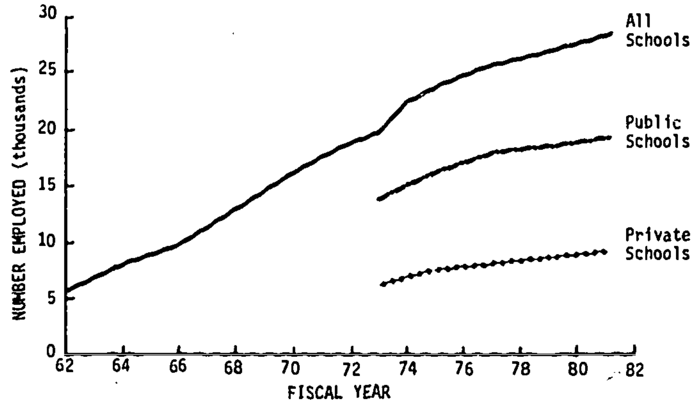
Ph.D. Production

The trend in Ph.D. production reflects the same general pattern that prevails in most other parts of the behavioral science area--up in the clinical fields and down in the nonclinical ones. In terms of total behavioral Ph.D. production, these trends tend to balance out. Total behavioral Ph.D. production has been essentially level since 1976 after a long period of growth, although both clinical and nonclinical Ph.D. production rose in 1981 (Figure 4.4). Clinical Ph.D. production in 1981 rose 10 percent over the 1980 level, continuing the rising trend that has been evident since 1975.

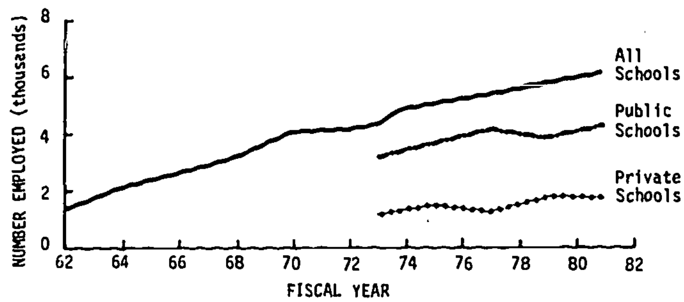
Nonclinical Ph.D. production showed an increase of 4.5 percent over 1980, but the long-term trend since 1975 has been one of gradual decline. The peak production was in 1976 (2,897) and no subsequent year has returned to that level. As 1981 is the only year since then in which there has been an increase in output over the preceding year, and even so is below the 1979 level, it appears to be minor upward fluctuation in a basically declining curve.

Postdoctoral Appointments

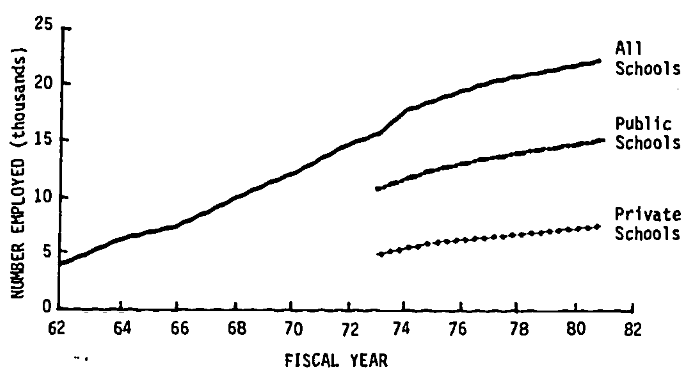
There is one item that reverses the general pattern--postdoctoral appointments in the clinical as well as the nonclinical fields dropped in 1981 (Figure 4.4). However, the growth rate in postdoctoral appointments since 1975 is almost twice as high in the clinical fields--8.5 percent per year compared to only 4.4 percent per year in the nonclinical ones (Table 4.2, lines 1c and 1f).



(a) Ph.D.s employed in all behavioral science fields at colleges and universities. See Appendix Table C7.

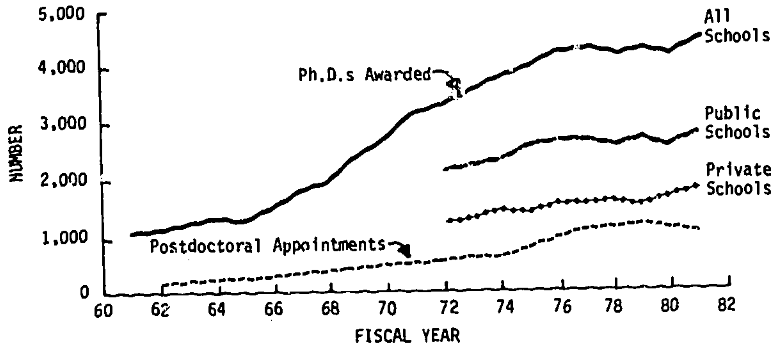


(b) Ph.D.s employed in clinical behavioral science fields at colleges and universities. See Appendix Table C8.

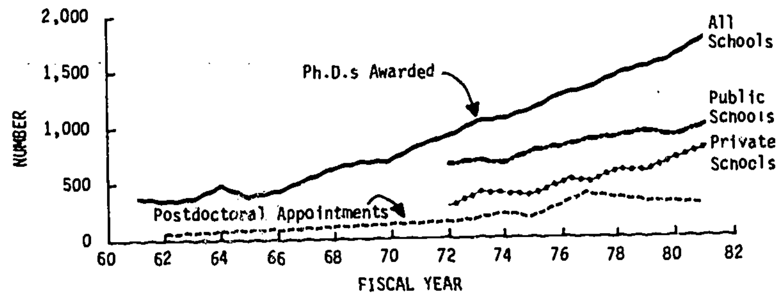


(c) Ph.D.s employed in nonclinical behavioral science fields at colleges and universities. See Appendix Table C9.

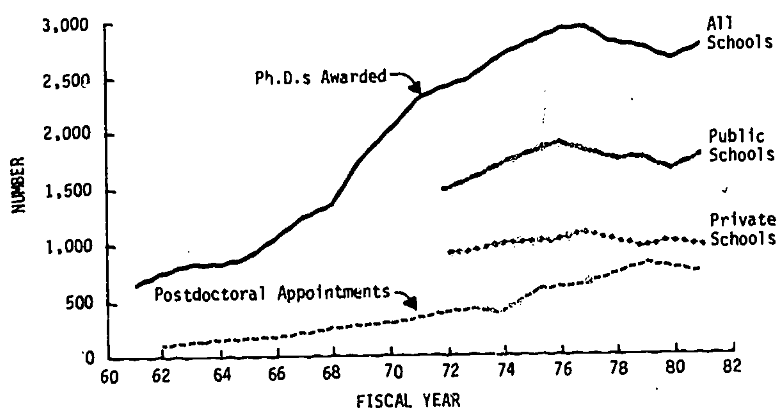
FIGURE 4.3 Ph.D.s employed in the behavioral sciences at colleges and universities, by control of institution, 1962-81.



(a) Postdoctoral appointments and Ph.D. degrees awarded in all behavioral science fields.



(b) Postdoctoral appointments and Ph.D. degrees awarded in clinical behavioral science fields.



(c) Postdoctoral appointments and Ph.D. degrees awarded in nonclinical behavioral science fields.

FIGURE 4.4 Behavioral science postdoctoral appointments and awarded Ph.D. degrees, 1960-81. See Appendix Tables C3 and C4.

R and D Expenditures

Behavioral science R and D expenditures in colleges and universities increased by almost 7 percent above inflation in 1981 from the previous year. This is the second straight year of increases after a long series of declines dating back to 1974 (Figure 4.5 and Table 4.1, line 2a).

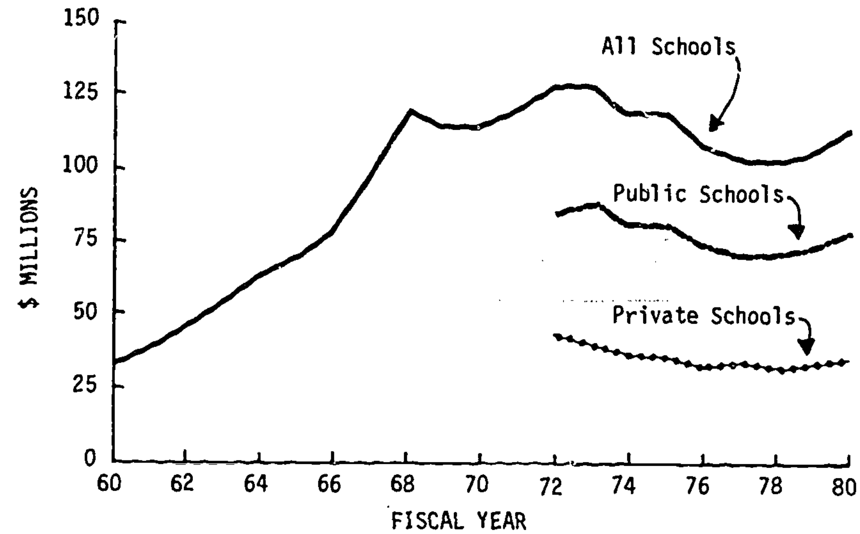


FIGURE 4.5 Behavioral science R & D expenditures in colleges and universities, by control of institution, 1960-80 (1972 $, millions). See Appendix Table C11.

Employment Sectors

In 1981 there was a large jump in the number of behavioral Ph.D.s who were self-employed--up almost [illegible] percent since 1979 (Table 4.1). Self-employment of clinical behavioral Ph.D.s has been growing sharply for some time. There are now more self-employed clinical behavioral Ph.D.s than are employed in any other sector including academia (Table 4.2, line 3p). Even many nonclinical Ph.D.s--for whom self-employment has not been a very significant factor--shifted into self-employment in 1981. For this nonclinical group, self-employment more than doubled in 1981 from the 1979 level. Employment in the business sector also showed large increases in 1981 for both types of behavioral scientists.

Short-Term Projections of Academic Demand

Having discussed the current market situation and given consideration to the issues surrounding predoctoral and postdoctoral training in the behavioral sciences, we turn now to an assessment of the near-term and long-term outlook for scientists in this area.

Because academic employment of behavioral science Ph.D.s has been increasing while enrollments have been declining, the Ph.D. faculty/student ratio (F/S) has moved sharply upward since 1972 (Appendix Table C10).

The explanation for the strong and continued growth in the F/S ratio has proven to be doggedly elusive. In the biomedical and clinical fields we have been able to construct models of academic demand based on the concept that such demand is dependent on three main academic activities: teaching, research, and, in the case of clinical faculty, patient care. The faculty/student ratios in these fields show a strong positive correlation with R and D expenditures and professional service income. But no such relationship can be demonstrated in the behavioral fields. The F/S ratio for behavioral Ph.D.s has continued to increase substantially during the 1970s, while R and D expenditures in the behavioral sciences at colleges and universities have been generally declining in real terms.

A plausible explanation is that Ph.D.s have been steadily replacing non-Ph.D.s on behavioral science faculties. This phenomenon--known as "enrichment"--has apparently been taking place at least since 1966. At that time, Ph.D.s constituted 56 percent of total behavioral science academic employment. Since then that percentage has steadily increased--by 1981 it was almost 75 percent (Table 4.3). So either the growth in academic employment of behavioral science Ph.D.s has been at the expense of non-Ph.D.s, or many non-Ph.D.s have attained their doctorate degree while academically employed during the last 15 years. Another small portion of the growth may be due to a shift to part-time rather than full-time employment.

These factors go part, but not all the way, toward a full accounting of the growth in academic employment of behavioral Ph.D.s over the last decade. After all, we still must confront the fact that total behavioral science academic employment--including <u>Ph.D.s and non-Ph.D.s</u>--although declining slightly in recent years, has remained at relatively high levels while estimated total behavioral enrollment has fallen rather sharply.

Another possible explanation is that our enrollment estimates are faulty. Data on undergraduate enrollment by fine field are not available from any source. The U.S. Office of Education collects data on <u>total</u> undergraduate enrollments and we have used these to estimate undergraduate enrollments in biomedical and behavioral fields as described in the footnote of Table 4.1. The resulting estimate approximates the number of students majoring in a field--it does not measure the number of <u>course</u> enrollments, which could be quite different. It is possible that in the behavioral fields, course enrollments (and hence the demand for teaching staff) have been increasing even though the number of students majoring in these fields has been decreasing. This possibility needs further study.

TABLE 4.3 Behavioral Scientists Employed in Colleges and Universities, 1961-81

Fiscal Year	Total[a] N	Total[a] %	Ph.D.s[b] N	Ph.D.s[b] %	Non-Ph.D.s N	Non-Ph.D.s %
1961	13,700	100.0				
1962	n/a		5,339			
1963	n/a		n/a			
1964	n/a		8,143			
1965	15,591	100.0	n/a			
1966	17,304[c]	100.0	9,783	56.5	7,521	43.5
1967	18,916	100.0	n/a		n/a	
1968	21,574[c]	100.0	12,915	59.9	8,659	40.1
1969	24,231	100.0	n/a		n/a	
1970	26,180[c]	100.0	16,175	61.8	10,005	38.2
1971	28,129	100.0	n/a		n/a	
1972	29,744[c]	100.0	18,602	62.5	11,142	37.5
1973	31,359	100.0	19,787	63.1	11,572	36.9
1974	32,980	100.0	22,324	67.7	10,656	32.3
1975	35,883	100.0	23,631	65.9	12,252	34.1
1976	38,121	100.0	n/a		n/a	
1977	39,240	100.0	25,588	65.2	13,652	34.8
1978	39,159	100.0	n/a		n/a	
1979	38,458[c]	100.0	26,894	69.9	11,564	30.1
1980	37,757	100.0	27,586[c]	73.1	10,171[c]	26.9
1981	37,976	100.0	28,277	74.5	9,699	25.5

[a]Includes psychologists and sociologists only.
[b]Includes psychologists, sociologists, and anthropologists.
[c]Interpolated.

SOURCES: NRC (1973-82), NSF (1965, 1978, 1982).

There seems to be some correlation between graduate enrollment and academic employment of Ph.D.s in the behavioral sciences but it is difficult to interpret. Although graduate enrollment is only 10 percent of the total behavioral science enrollment, its growth pattern over the past 10 years has been roughly parallel to the growth in academic employment. It is possible that increasing graduate enrollments have created accompanying academic vacancies for people to teach them. Given the time lag in budgetary responses to teaching demands and the predominant role played by undergraduate enrollments in affecting the creation of teaching positions, this possibility seems, prima facie, to be of low probability. Alternatively, it is possible that growth of faculty positions, determined by a mix of

other factors, creates a situation wherein more applicants for admission to graduate study are accepted and in this way the size of the academic staff determines the number of graduate students admitted. Neither the direction of causality nor even a conclusion of causality can be determined from the available information.

In summary, it appears that the continued growth in academic employment of behavioral science Ph.D.s is at least partially due or related to four factors: (1) enrichment or upgrading, (2) somewhat greater reliance on part-time employment, (3) underestimated course enrollments, and (4) growth in graduate enrollment. There is good evidence that enrichment has been an important factor, and that part-time employment has increased (see Appendix Table C13). The connection between graduate enrollment and academic demand is purely speculative and needs to be verified by further study, along with our estimate of undergraduate enrollments.

The Model of Academic Demand for Behavioral Ph.D.s

This brings us to the issue of how to make projections of academic demand for behavioral science Ph.D.s. For this report we will continue our past practice which has been simply to make independent assumptions about future patterns of enrollments and the F/S ratio. Then these projected values are combined to produce projections of academic employment levels, usually for 5 years ahead of the date of publication of the report. This procedure yields estimates of academic levels due to expansion (or contraction) of faculty. To this we must add demand created by attrition, which we estimate from recent actual experience.

Recently, we have obtained more detailed information about the inflows and outflows in the academic labor market for behavioral scientists. The data from the 1979 and 1981 Surveys of Doctorate Recipients show that a fairly substantial amount of field switching out of behavioral fields has been occurring which must be considered in estimating attrition rates. There is, of course, also a substantial amount of switching into behavioral fields, and this will be accounted for when we consider how the total number of vacancies occurring each year are filled.

To implement this projection procedure, therefore, we must formulate high, middle, and low assumptions about enrollment patterns and future F/S levels. For analysis purposes, the faculty/student ratio will be constructed as F/WS defined as follows:

F = Ph.D.s employed by academic institutions in behavioral science fields (excluding postdoctoral trainees)

WS = 4-yr weighted average of enrollments, i.e.

$WS_t = 1/6\ (S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$

where S = behavioral science undergraduate and graduate enrollments.

Assumptions

The Committee's best guess is that total behavioral science enrollments will decline slightly from their 1980 level to about 625,000 by 1988. The upper and lower limits on this estimate are 700,000 and 550,000, respectively (Figure 4.6).

As of 1980--the latest year we can compute it--the F/WS value in the behavioral fields was 0.044 (Figure 4.7). We expect it to stay at about this level for the next 5 years within a range of 0.035 to 0.055.

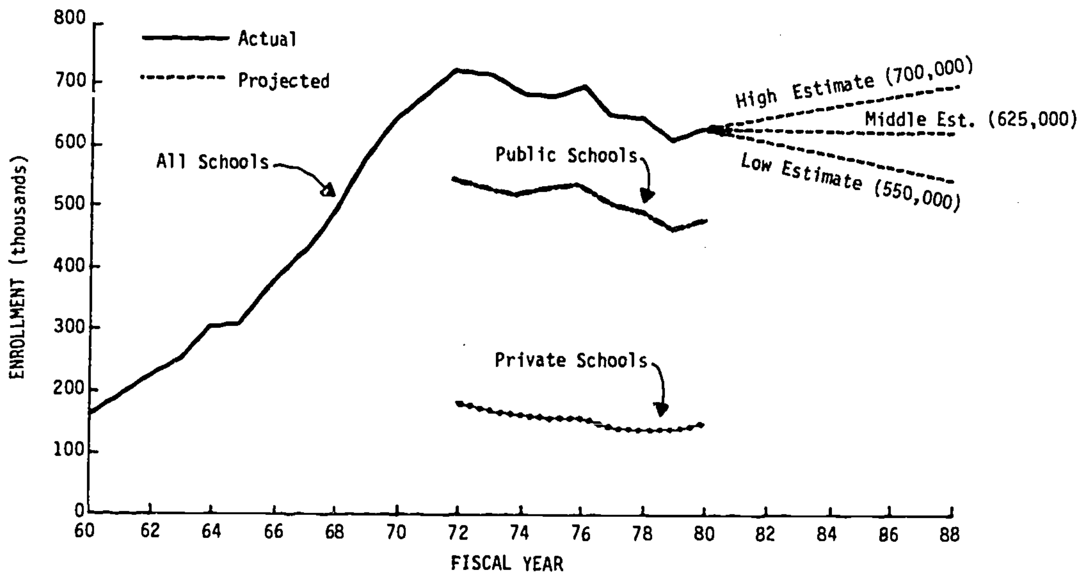


FIGURE 4.6 Total behavioral science undergraduate and graduate enrollments in colleges and universities, by control of institution, 1960-80, with projections to 1988. See Appendix Table C1.

Projections of Academic Demand to 1988

The combination of three estimates of enrollment growth together with three estimates of the 1988 F/WS level provides nine estimates of academic employment of behavioral science Ph.D.s in 1988 as shown in Table 4.4.

Under the high assumptions (I-A of Table 4.4), enrollments would grow to 700,000 and the F/WS ratio would be 0.055, yielding an estimated faculty size of 37,700 behavioral science Ph.D.s in 1988 (Figure 4.8). This would represent a growth of about 1,270 per year from the 1980 level of 27,600. Deaths and retirements would generate 330 vacancies, and other attrition from academic employment and field switching would add 1,240 vacancies, for a total annual demand of 2,840 positions.

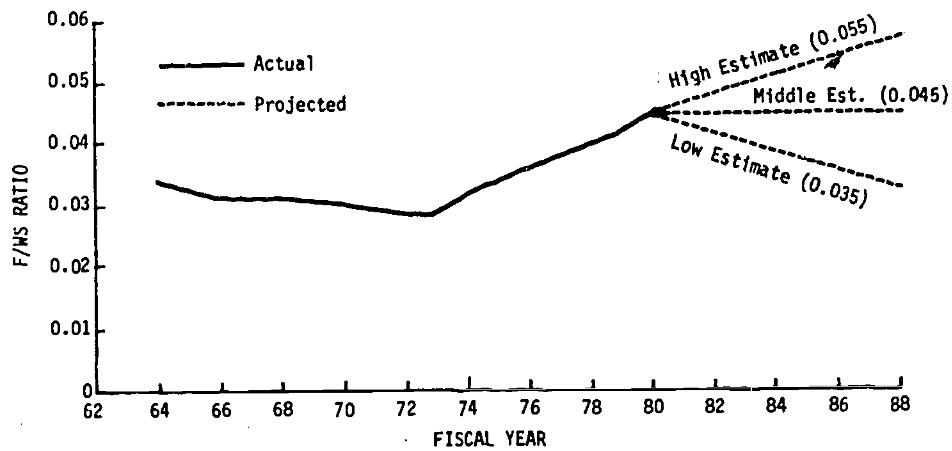


FIGURE 4.7 Behavioral science Ph.D. faculty/student ratio (F/WS), 1964-80, with projections to 1988. Faculty (F) is all Ph.D.s employed in the behavioral sciences at colleges and universities. Students (WS) are defined as a 4-year weighted average of enrollments in the behavioral sciences: $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$ where S_t = total behavioral graduate and undergraduate enrollments in year t. See Appendix Table C10.

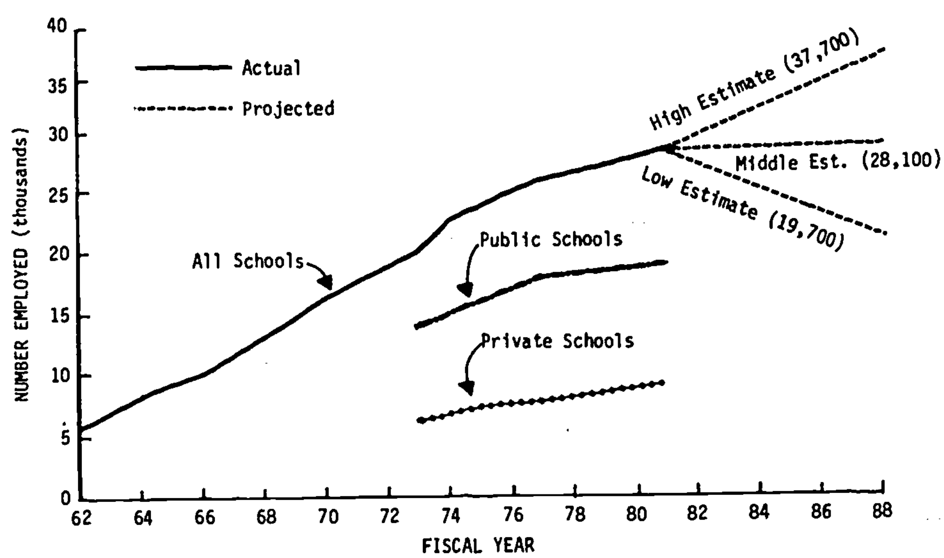


FIGURE 4.8 Ph.D.s employed in all behavioral science fields at colleges and universities, by control of institution, 1962-81, with projections to 1988. See Appendix Table C7.

TABLE 4.4 Projected Growth in Behavioral Science Ph.D. Faculty, 1980-88, Based on Projections of Enrollment and Faculty/Student Ratios[a]

Assumptions about Behavioral Science Undergraduate and Graduate Enrollment (estimated at 627,300 in 1980)		Assumptions about the Faculty/Student Ratio for Behavioral Ph.D.s in Colleges and Universities (0.044 in 1980): I Will continue to grow, reaching 0.55 by 1988	II Increases slightly to 0.045 by 1988	III Declines to 0.035 by 1988
A. Will grow to 700,000 students by 1988	Expected size of behavioral science faculty (F) in 1988	37,700	30,900	24,000
	Annual growth rate in F from 1980 to 1988	4.0%	1.4%	−1.7%
	Average annual increment due to faculty expansion	1,270	410	−450
	Annual replacement needs due to:[b]			
	death and retirement	330	290	260
	other attrition	1,240	1,110	980
	Expected number of academic positions to become available annually for behavioral Ph.D.s	2,840	1,810	790
B. Will remain at about the 1980 level (625,000) through 1988	Expected size of behavioral science faculty (F) in 1988	34,400	28,100	21,900
	Annual growth rate in F from 1980 to 1988	2.8%	0.2%	−2.8%
	Average annual increment due to faculty expansion	850	70	−710
	Annual replacement needs due to:[b]			
	death and retirement	310	280	250
	other attrition	1,180	1,060	940
	Expected number of academic positions to become available annually for behavioral Ph.D.s	2,340	1,410	480
C. Will decline to 550,000 students by 1988	Expected size of behavioral science faculty (F) in 1988	31,000	25,400	19,700
	Annual growth rate in F from 1980 to 1988	1.5%	−1.0%	−4.1%
	Average annual increment due to faculty expansion	430	−280	−980
	Annual replacement needs due to:[b]			
	death and retirement	290	260	240
	other attrition	1,110	1,010	900
	Expected number of academic positions to become available annually for behavioral Ph.D.s	1,830	990	160

[a] Faculty is defined in this table as all academically employed Ph.D.s, excluding postdoctoral appointees. The denominator of the faculty/student ratio is a weighted average of the last 4 years of enrollments: $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = total graduate and undergraduate enrollments in the behavioral sciences. See Appendix Tables C1 and C10.

[b] Based on an estimated replacement rate of 1.0% annually due to death and retirement, and 3.8% annually due to other attrition from academic positions in the behavioral sciences. These estimates were derived from the National Research Council (1973-82).

In the best-guess case (II-B of Table 4.4), enrollments would remain at about 625,000 and the F/WS ratio would be 0.045 by 1988. Academic employment would expand by 70 Ph.D.s per year, with another 1,340 added by attrition from all sources, for a total annual demand of 1,410.

Under the lowest combination of assumptions (III-C of Table 4.4), enrollments would drop to 550,000 and the F/WS ratio would decline to 0.035 by 1988. There would be a drop of about 980 academic positions per year due to faculty contraction, but attrition would add about 1,140 vacancies per year, leaving a net annual demand of 160 positions to be filled.

Estimating Postdoctoral Support Levels Under NRSA Programs

The final step in our quantitative analysis of the market is to attempt to translate the projections of academic demand into recommended levels of postdoctoral training under NRSA programs, as shown in Table 4.5. This step requires certain additional assumptions about how the system has functioned in recent years with regard to postdoctoral training and its sources of support.

TABLE 4.5 Estimated Number of Behavioral Science Postdoctoral Trainees Needed to Meet Expected Academic Demand Through 1988 Under Various Conditions

	Projected Through 1988			
	High Estimate	Middle Estimate	Low Estimate	Annual Average 1979-81
1. Academic demand for behavioral science Ph.D.s–annual average:	2,840	1,410	160	1,919
a. due to expansion of faculty	1,270	70	–980	691
b. due to death and retirement[a]	330	280	240	238
c. due to other attrition[b]	1,240	1,060	900	990
2. Total accessions with postdoctoral research training–annual average[c]	710	350	40	364[d]
3. Size of behavioral science postdoctoral pool–annual average				
Size needed to meet academic demand assuming a 2-yr. training period and portion of trainees seeking academic positions is:				1,080
a. 60%	2,370	1,170	130	
b. 70%	2,030	1,000	110	
4. Annual number of behavioral science postdoctoral trainees to be supported under NRSA programs:				349
a. if 40% of pool is supported under NRSA	810-950	400-470	40-50	
b. if 50% of pool is supported under NRSA	1,010-1,190	500-580	50-70	
c. if 60% of pool is supported under NRSA	1,220-1,420	600-700	70-80	

[a] Assumes an attrition rate due to death and retirement of 1.0% per year.
[b] Assumes an attrition rate due to other causes of 3.8% per year.
[c] Assumes that 25% of all vacancies, including those created by field switching, will be filled by individuals with postdoctoral research training in the behavioral sciences. The remaining 75% will be filled from nonacademic sectors (18%), unemployed (2%), and new Ph.D. recipients (55%).
[d] Assumes that 15% of the 1979-81 Ph.D. cohorts took a postdoctoral appointment before taking an academic position. This estimate is based on data from the National Research Council (1958-82, 1973-82).

SOURCE: Table 4.4.

The features of the system which must be considered in addition to the projections of faculty growth are as follows:

1. the number of accessions to academic positions who have (or should have) research training
2. the appropriate length of the postdoctoral research training period
3. the proportion of individuals in the research training pipeline who aspire to academic careers
4. the proportion of support of the total pool of behavioral science research trainees that should be provided by the federal government.

With the aid of the data on inflows and outflows from academic employment of behavioral science Ph.D.s during 1979-81, shown in Table 4.6, we can make reasonable assumptions about these features--first presented in the Committee's 1981 Report--in order to provide a quantitative basis for the recommendations.

Using the projections of academic demand derived in Table 4.4, we calculate in Table 4.5 the range of behavioral science postdoctoral trainees that should be supported by NRSA programs under the specified conditions.

Line 1 of Table 4.5 is a summary of the projections of academic demand for the extreme cases and the best-guess estimate derived in Table 4.4.

Line 2 shows the number of academic positions to be filled by individuals with postdoctoral research training experience assuming that 25 percent of all vacancies will be filled by former postdoctoral trainees. In the best-guess case, this number is estimated to be about 350.

Line 3 indicates the size of the behavioral science postdoctoral pool required to supply the necessary number of individuals with postdoctoral training under certain assumptions about the length of the postdoctoral training period and the proportion of the pool seeking academic employment.

If the appropriate length of postdoctoral training is 2 years, then the pool size needed to produce 350 trained scientists per year would be 700. If only 60 percent of the trainees seek academic appointments after completing their training, then the necessary pool size must be 1,170.

Line 4 shows the estimated number of behavioral science postdoctoral trainees that should be supported annually by NRSA programs under different assumptions about the proportion of total support provided by that source. The resulting range is between 40 under the lowest set of assumptions, and 1,420 under the highest set. The best-guess assumptions yield a range of 400-700 postdoctoral trainees in the behavioral sciences. This range results from different judgments about the share of postdoctoral training support in the behavioral sciences that should be provided by the federal government through NRSA programs. Based on the contributions of these programs to the quality of postdoctoral training, the Committee believes that 50 percent is the appropriate federal share, yielding 500-580 NRSA awards per year.

TABLE 4.6 Inflows and Outflows from Academic Employment for Behavioral Science Ph.D.s, 1979-81

I. *Average Annual Attrition from Academic Employment in the Behavioral Sciences*

1. Total behavioral Ph.D.s employed in academia in 1979: 26,894

2. Leaving academic employment between 1979 and 1981 in the behavioral sciences to:

	N	% of Academic Employment
a. nonacademic employment	664	2.5
b. postdoctoral appointment	40	0.1
c. death and retirement	238	1.1
d. other fields[a]	184	0.7
e. unemployed	102	0.4
f. total attrition	1,228	4.8

II. *Average Annual Accessions to Academic Employment in the Behavioral Sciences*

1. Total behavioral Ph.D.s employed in academia in 1981: 28,277

2. Entering academic employment between 1979 and 1981 in the behavioral sciences from:

	N	% of Total Accessions
a. nonacademic sectors	352	18.3
b. postdoctoral appointments	160	8.3
c. unemployed	45	2.3
d. Ph.D. recipients 1979-81[b]	1,362	71.0
e. total annual accessions	1,919	100.0

III. *Balancing*: 1979 academic employment – attrition + accessions = 1981 academic employment

26,894 – 2(1,228) + 2(1,919) = 28,276[c]

[a]These individuals were all academically employed in 1979 and 1981. The number shown represents the net number switching from behavioral to nonbehavioral fields.
[b]It is estimated that 15% of these new Ph.D. cohorts took a postdoctoral appointment before taking an academic position.
[c]Does not agree with line II.1 because of rounding.

SOURCES: National Research Council (1958-82, 1973-82).

Summary

In the above analysis, we have attempted to project short-term trends in academic employment of behavioral science Ph.D.s and to translate them into postdoctoral training levels needed to satisfy academic demand under certain specified conditions.

The data on trends in academic employment are carefully collected and are probably quite reliable--especially since 1972--but they are difficult to interpret. The growth in academic employment in the behavioral fields during the 1970s has occurred despite an apparent drop in total behavioral enrollments and does not seem to be related to research expenditures. Enrichment--the process of enlarging the proportion of Ph.D.s in academic positions--has obviously been taking place and can account for much of the growth. Graduate enrollment in the behavioral fields has also continued to grow, possibly providing some stimulus for faculty expansion.

The best-guess projection yields a modest increase in academic employment of behavioral science Ph.D.s by 1988. Converting the projections of academic demand into recommended postdoctoral training levels requires certain assumptions about how the system has operated in the past and how it can be expected to operate in the next few years. The actual data on dynamic movements into and out of the academic labor market during 1979-81 give new insight into the recent operation of this market. If we base the estimates on these recent data, we find that the level of postdoctoral training that should be provided under NRSA programs in the best-guess case is somewhat higher than current numbers actually being funded by the federal agencies.

Demand Outside the Academic Sector

Of particular interest to the Committee and its Panel on Behavioral Sciences is the steady increase in employment outside the academic sector. During the 1973-81 span the number of Ph.D. scientists in behavioral fields who were employed in nonacademic settings grew at an average annual rate of more than 10 percent, while the number employed by academic institutions rose at a rate of only 4 percent (see Appendix Table C7). Within the nonclinical areas in the behavioral sciences, expansion outside the academic sector has been especially great in the last 2 years. Between 1979 and 1981 the numbers of nonclinical scientists holding positions in business, government, and other nonacademic settings grew at a yearly rate of nearly 10 percent. The implications of this trend with regard to need for federal training support in the behavioral sciences rest, in part, on whether or not the movement toward nonacademic employment represents an appreciable decline in the fraction of behavioral scientists involved in research. To address this issue a detailed analysis has been made of 1973-81 trends in the employment situations of behavioral science Ph.D. recipients entering the labor force. It is presumed that these new entrants would have been most vulnerable to significant changes in the availability of career opportunities.

Findings from this analysis are summarized in Table 4.7. As can be seen from the data presented, there has been an appreciable decline in recent years in the percentages of behavioral science Ph.D. recipients taking faculty positions. This decline has been particularly noticeable in the nonclinical areas of the behavioral sciences. In these disciplines the fraction of new entrants employed in faculty positions dropped from approximately two-thirds in 1973 to only one-third by 1981. This drop has been offset, in part, by increases in the percentages taking postdoctorals and other nonfaculty staff positions in universities and colleges. By 1981 more than one-fourth of the new Ph.D. cohort who had entered from the nonclinical fields held academic positions not considered to be faculty appointments. During this 8-year span there also have been substantial increases in the numbers of both clinical and nonclinical Ph.D. recipients who took positions outside the academic sector--and many of those in the nonclinical fields were engaged in research. Thus, although the findings indicate that an appreciably smaller fraction of behavioral science graduates have moved on to university faculty appointments, there has been a modest increase in the fraction involved in research outside the academic setting.

Although the unemployment rates for behavioral science Ph.D.s have never exceeded 4 percent, it may be noted that the rates for Ph.D. recipients in nonclinical fields have been generally higher than the rates for clinical graduates. These findings are consistent with the committee's impression that the employment prospects for those trained in clinical areas have been much better than the prospects for other behavioral science graduates. Further evidence of this may be discerned from an examination of the field-switching patterns of recent graduates. As shown in column (2) of Table 4.8, the percentage of Ph.D. recipients in nonclinical areas of the behavioral sciences who left these fields within 2 years after receipt of their doctorates has increased from 22 percent for the FY 1971-72 cohort to as much as 37 percent for the FY 1979-80 cohort. During this 8-year span the percentage leaving the clinical fields has never exceeded 14 percent. A detailed analysis (not presented here) of field-switching patterns reveals that more than half of the recent graduates leaving the nonclinical areas of the behavioral sciences were either psychologists moving into clinical specialties and the life sciences or anthropologists and sociologists switching into other areas of the social sciences.

One useful barometer of the changing demand for Ph.D. recipients in a field is the ratio of the number of recent graduates employed in that field to the number trained in the field. As shown in column (5) of Table 4.8, this ratio has dropped significantly during the past decade in the nonclinical fields. By the late 1970s the number of new graduates employed in these fields represented only about two-thirds of the number of individuals who had received their doctorates in the nonclinical fields. In contrast, throughout this period there have been significantly more young graduates working in the clinical fields of the behavioral sciences than had been trained in these fields. In view of these findings it is not surprising to find that an increasingly larger fraction of the graduate students enrolled in the behavioral sciences have earned their doctorates in the clinical fields.

TABLE 4.7 Employment Situations of Behavioral Ph.D. Recipients Who Had Received Their Doctorates Within the Previous 2 Years, 1973-81

	Fiscal Year									
	1973		1975		1977		1979		1981	
Employment Situation	N	%	N	%	N	%	N	%	N	%
PH.D.S IN CLINICAL FIELDS										
Total Entrants	1,793	100.0	2,051	100.0	2,427	100.0	2,621	100.0	2,936	100.0
Academic Sector	547	30.5	604	29.4	752	31.0	585	22.3	750	25.5
Faculty Positions	441	24.6	477	23.3	590	24.3	229	8.7	519	17.7
Postdoctorals	9	0.5	26	1.3	15	0.6	24	0.9	12	0.4
Other Staff[a]	97	5.4	101	4.9	147	6.1	332	12.7	219	7.5
Nonacademic Sectors	1,211	67.5	1,437	70.1	1,634	67.3	1,956	74.6	2,186	74.5
Research Positions[b]	n/a	n/a	268	13.1	237	9.8	217	8.3	155	5.3
Other Staff Positions	n/a	n/a	1,169	57.0	1,397	57.6	1,739	66.3	2,031	69.2
Unemployed and Seeking Position	35	2.0	10	0.5	41	1.7	80	3.1	0	0.0
PH.D.S IN NONCLINICAL FIELDS										
Total Entrants	3,569	100.0	4,236	100.0	4,479	100.0	4,786	100.0	4,627	100.0
Academic Sector	2,727	76.4	3,059	72.2	3,004	67.1	3,212	67.1	2,757	59.6
Faculty Positions	2,387	66.9	2,425	57.2	2,146	47.9	2,212	46.2	1,578	34.1
Postdoctorals	97	2.7	284	6.7	286	6.4	385	8.0	433	9.4
Other Staff[a]	243	6.8	350	8.3	572	12.8	615	12.8	746	16.1
Nonacademic Sectors	786	22.0	1,106	26.1	1,294	28.9	1,408	29.4	1,761	38.1
Research Positions[b]	n/a	n/a	702	16.6	695	15.5	519	10.8	976	21.1
Other Staff Positions	n/a	n/a	404	9.5	599	13.4	889	18.6	785	17.0
Unemployed and Seeking Position	56	1.6	71	1.7	181	4.0	166	3.5	109	2.4

[a]Includes individuals employed in academic positions that were not considered faculty (tenure track) or postdoctoral appointments.
[b]Includes individuals employed in nonacademic sectors who indicated that they devoted at least one-fifth of their time to R and D activities.

SOURCE: National Research Council (1973-82).

TABLE 4.8 Field Switching into and out of Clinical and Nonclinical Areas of the Behavioral Sciences by FY 1971-80 Ph.D. Recipients[a]

Ph.D. Cohort	(1) Total Ph.D.s in Field	(2) Leaving Field		(3) Switching into Field	(4) Total Empl. in Field	(5) Ratio (4)/(1)
	N	N	%	N	N	
FY 1971-72						
Clinical Fields	1,758	236	13.4	333	1,855	1.06
Nonclinical Fields	3,513	791	22.5	309	3,031	0.86
FY 1973-74						
Clinical Fields	2,041	202	9.9	547	2,386	1.17
Nonclinical Fields	4,165	1,037	24.9	269	3,397	0.82
FY 1975-76						
Clinical Fields	2,386	261	10.9	617	2,742	1.15
Nonclinical Fields	4,298	1426	33.2	298	3,170	0.74
FY 1977-78						
Clinical Fields	2,541	350	13.8	721	2,912	1.15
Nonclinical Fields	4,620	1,782	38.6	323	3,161	0.68
FY 1979-80						
Clinical Fields	2,936	189	6.4	472	3,219	1.10
Nonclinical Fields	4,518	1,678	37.1	191	3,031	0.67

[a]Data reflect field of employment within 2 years of the time an individual received the doctorate.

SOURCE: National Research Council (1973-82).

Long-Term Considerations

In considering the implications of market trends in the behavioral sciences, we must note that there is, on average, a 7-year lag from the time a student enters graduate school to the time he or she completes requirements for the doctorate. Consequently, undergraduate students now contemplating research careers in the behavioral sciences are not likely to be looking for jobs until the early 1990s. Although we are reasonably confident about our short-term projections of academic demand, the long-term outlook is much more difficult to quantify. But certain trends are developing now which, if continued to the 1990s, could have great impact on the market for behavioral scientists. During the past decade, for instance, we have witnessed an expansionary trend that few could have predicted in the employment of behavioral scientists outside the academic sector. Much of this growth has been in the non-research areas of the behavioral sciences and, as such, may not affect the demand for research personnel. The

factors underlying this trend are not fully known, and it is difficult to foresee whether this trend will continue during the next 15 years.

Far more predictable, on the other hand, are the numbers of individuals who will leave the Ph.D. labor force during this period. Estimates of attrition due to deaths and retirements based on the age distribution of the FY 1981 labor force are illustrated in Figure 4.9.[3] Between 1982 and 2001 the number of clinical and nonclinical

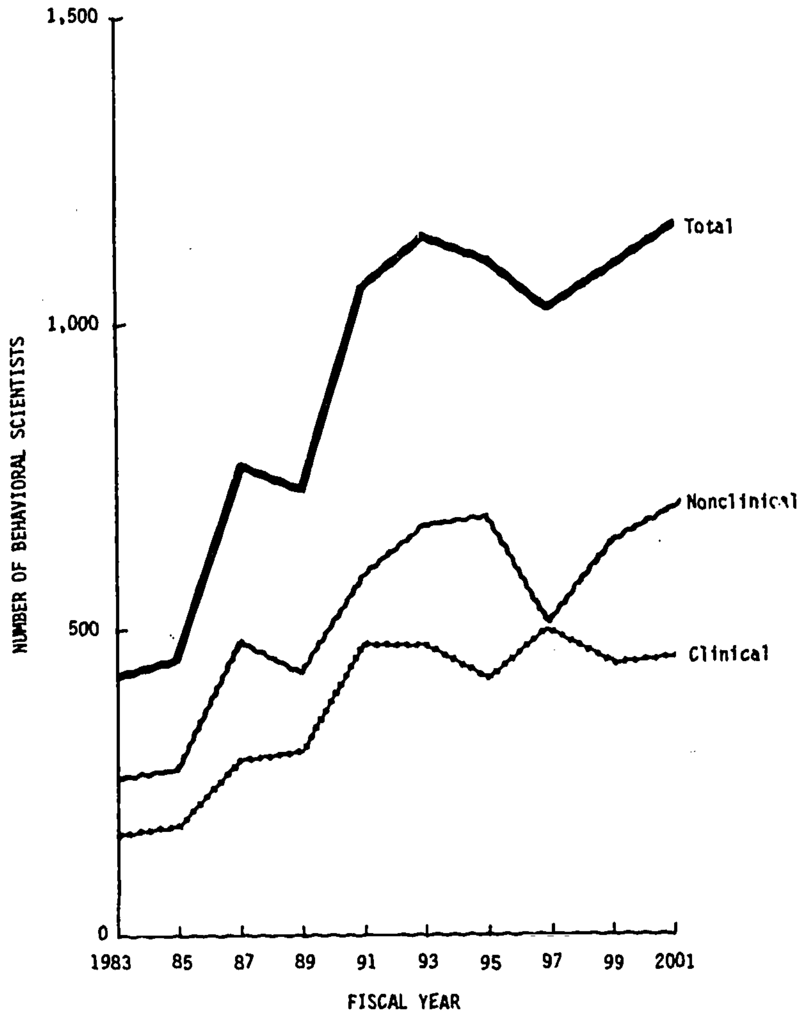


FIGURE 4.9 Annual number of behavioral scientists in the FY 1981 Ph.D. labor force expected to reach the age of 65 during the FY 1983-2001 period. See Appendix Table C14.

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[3] The attrition rate used in the short-term projections through 1988 was based on a fixed percentage of the academic labor force. Long-term attrition estimates must consider the age distribution of the total Ph.D. labor force of behavioral scientists.

behavioral scientists who will reach the age of 65 is expected to increase appreciably. By the end of this period the estimated annual attrition will be nearly three times the 1983 level. Between 1992 and 2001, a total of 11,000 behavioral Ph.D.s are likely to be lost through attrition due to death and retirement, compared with 6,900 in the preceding 10-year span. This substantial rise in attrition is likely to occur during a period when a diminishing number of individuals will be receiving doctorates in the behavioral sciences. Annual Ph.D. production in the behavioral sciences is projected to decline from 4,469 in FY 1981 to approximately 3,700 awards by FY 1988 (Figure 4.10). In the nonclinical areas, a drop in doctoral awards of

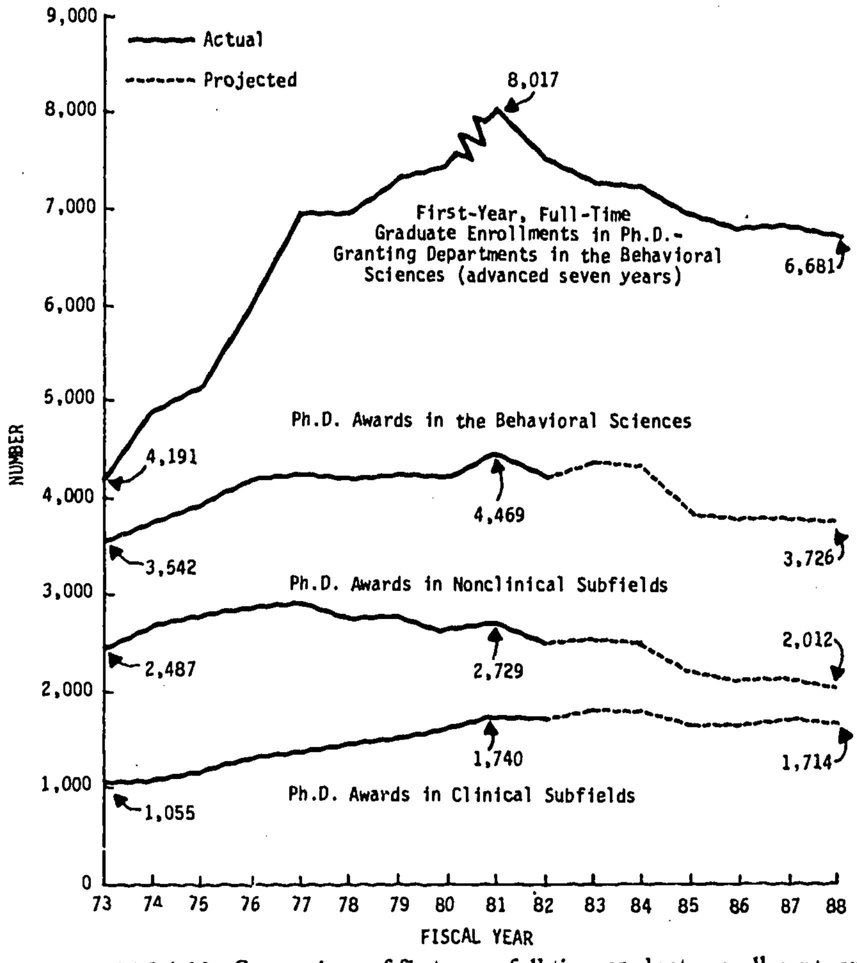

FIGURE 4.10 Comparison of first-year, full-time graduate enrollments and Ph.D. awards in the behavioral sciences, 1973-88. See Appendix Tables C2 and C4.

more than 25 percent is expected, while in the clinical areas the projected decline is very slight.[4] In making projections for the subfields it has further been assumed, on the basis of recent trends, that an increasingly larger fraction of the behavioral science Ph.D.s will be awarded in clinical areas. During the last 10 years the percentage of behavioral science doctorates in clinical fields has steadily increased from 30 percent to its current level of 40 percent.

These projections are tentative and should be interpreted cautiously. Whether an overall decline of 18 percent in Ph.D. awards in the behavioral sciences occurs will depend on a variety of factors such as the availability of financial support for graduate study, the average time it takes students to finish their doctoral programs, and other factors affecting the "completion rate" for first-year graduate students in the behavioral sciences. If, for example, past trends continue and a decreasing fraction of the graduate students currently enrolled complete work for the Ph.D., the decline in doctoral awards may be even greater than projected. Furthermore, it should be recognized that even if the annual number of doctoral graduates is greatly reduced, this number will still exceed the total labor force attrition (due to death and retirement) which is expected to average fewer than 700 scientists per year between now and 1988. Thus, continued expansion in the behavioral science labor force may be anticipated, although at a rate somewhat below that experienced during the past decade. But if recent trends continue, Ph.D. awards in the nonclinical specialties may be expected to drop far more sharply than doctoral awards in the clinical specialties. In fact, it is highly probable that by the mid-1990s more individuals will earn Ph.D. degrees in the clinical fields than in the other behavioral sciences. This prospect is of particular concern since the largest share of the research in the behavioral sciences is conducted by individuals with training in the nonclinical areas. On the basis of these long-term considerations, the Committee concludes that there is a continuing need for federal training support at the predoctoral level in the behavioral sciences.

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[4] It has been assumed in these projections that there is a 7-year lag between the time a student initially enrolls in graduate school and the date of completion of the doctoral program. It has also been assumed that approximately 56 percent of the students enrolling will successfully complete their doctoral programs. The latter assumption is based on the ratio of Ph.D. awards in FY 1981 and FY 1982 to first-year full-time graduate enrollments 7 years earlier.

5. Health Services Research

The field of health services research (HSR) is in a paradoxical situation. Problems that can be addressed in this field are increasing in number and variety at a time when funds for research have been sharply reduced. The short-run outlook for funding of health services research is not bright, but there is a good chance that the demand for HSR will expand substantially in the next decade. Training in HSR should be directed to provide broad research skills to health professionals and others. More information is needed about the programs for training and research conducted in university-related health services research centers.

INTRODUCTION

Health services research is concerned with issues involved in the health care system. This system is in many respects excellent, yet it has many faults. It is the role of health services research (HSR) to identify, explain, and suggest remedies for those faults. HSR has led to some basic understanding of these problems. For example, those who are both poor and nonwhite receive the least health care in relation to their needs. There are too many hospital beds in some areas. Well tested disease prevention measures are not applied widely enough. Above all, the system of health care and delivery is extremely costly in relation to the volume and quality of care that is delivered. The total health care costs of the nation now exceed $250 billion per year--a quarter of a trillion dollars.[1] Clearly, the goals, practices, and efficiency of governmental health activities are both a national economic issue of high importance and a major determinant of the quality and availability of health care.

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[1] All figures in this section are from the U.S. Bureau of the Census, 1981, pp. 99, 276, 421, 424.

Efforts to make the system more effective should rest upon a research base. Many policy choices of broad scope are properly political decisions because they affect the interests of important contending parties. But the framing of alternative proposals and many of the considerations influencing choices should rest upon research--the collection, analysis and interpretation of relevant facts. Research can illuminate the cost and the effectiveness of alternative approaches, provide a factual, analytical base for the debates, and reduce areas of speculation and uninformed polemics. Otherwise choices are made with insufficient information and mistakes are made that can cause great harm in both human and economic terms.

THE SCOPE OF HEALTH SERVICES RESEARCH

Examples

Health Services Research, dealing as it does with a diverse and complex area of human activity, encompasses a wide range of inquiry and many research methods. It includes such significant fields of inquiry as the definition and determinants of the effectiveness and efficiency of prepaid medical care plans, various approaches to health insurance, health maintenance organizations and group practice, the role and scope of primary care, the assignment of patient care tasks to various health professionals, the efficiency of hospital operations, and nursing delivery systems.

A sense of the breadth of the field and the multiplicity of approaches can be provided by describing a few of these important areas of investigation.

Access and Equity

The continuing national debate over the availability of medical care to various population groups has been fueled in part by health services research. These studies have also provided one of the bases for legislation and administrative action. For example, Medicare and Medicaid are more than systems which generate problems of cost containment. They are social measures designed to make medical care available to old people and poorer people.

Studies which showed that low socioeconomic status was related to low physician utilization were followed by investigations that showed areas of improvement over the years.[2] For example, in 1976, the fifth of a series of national household surveys shed further light on

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[2] One of the most significant of these analyses was: Ronald Andersen, Joanna Kravits, and O. W. Anderson, 1975.

the use of expenditures for and satisfaction with formal medical care and on the appropriateness of the care.[3]

It showed that there have been substantial improvements in access in the U.S. over the past 25 years, but that pockets of inequity remain. The report was widely disseminated and commented upon. Although the meaning of the findings for health policies was interpreted differently by different interests, the validity and relevance of the study for health services delivery decision making were generally accepted by all. The study contributed vital information to the current debates over national health insurance and other large-scale health policy measures.

Cost Containment

There is an urgent national need to control hospital costs without reducing the quality or volume of needed hospital services and without disrupting the hospital system itself. One approach is to pay hospitals the same amount for similar cases. This can be done, in theory, by classifying hospital cases into a manageable number of categories that are reasonably homogeneous in resource use and cost, and then establishing how much will be paid for cases in each category.

A reduction of the theory to a useable system has been a formidable task. One research team, having worked on the problem for several years (HCFA, 1982, pp. 7 and 48), developed a system of diagnostically related groups (DRG's) using data from 500,000 discharge records. Legislation based upon the concepts and specifications developed by this effort in health services research was enacted on March 9, 1983.

High Technology and Health Care

While the rapid advance of technology has extended the capability to deal with hitherto intractable health problems, it has raised questions of resource allocation and cost containment. These in turn are complicated by ethical considerations. Health services research has generated information relevant to these problems. Renal dialysis is a case in point. Research showed that between 1973 and 1977, the proportion of patients dialyzing at home dropped from 36 to 13 percent (HCFA, 1982, pp. 7 and 48). The decline was the result of a Medicare amendment in 1972 which penalized patients who dialyzed at home. Additional research showed that dialysis in a medical facility costs $22,000 per patient per year while home dialysis costs $11,800 per year. As a consequence of these analyses, Congress in 1978 enacted legislation to encourage home treatment, and per patient costs subsequently declined by 3.5 percent in 1979.

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[3] The study, Health Care in the United States: Equitable for Whom, was financed by the Robert Wood Johnson Foundation and the National Center for Health Services Research. It was conducted by the Center for Health Administration Studies of the University of Chicago, and was based upon interviews with 8,000 people in 5,000 families. For an earlier assessment of problems of access, see Thomas W. Bice, Robert L. Eichhorn, and Peter D. Fox, 1972.

Definition, Methods, and Goals

Describing the field in more general terms, health services research examines ways in which the organization, delivery, and financing of health services affect the equity, effectiveness, and costs of the personal health services systems of the country. The inquiries produce knowledge about the structure, processes, or effects of personal health services. In other words, systematic methods are applied to problems involved in the allocation of finite health resources with the aim of improving the health care delivery system and making information available for future adjustments to the system.

In terms of approach, the special capacities and insights of a wide array of disciplines are brought to bear upon problem areas.[4] Most health services research is interdisciplinary. The research techniques include health statistics, statistical indicators (including health status indicators), statistical modeling, case studies, clinical studies, social experimentation, survey research, evaluation research (including program evaluation), technology assessment, decision analysis, and policy analysis.

Much health services research, such as that described in the preceding section, involves pathfinding inquiry into basic concepts, the development of new research methods, the solution of definitional problems, and the testing of hypotheses related to important aspects of health care. This can be called policy research. These types of investigations often require collaboration among people from different disciplines. Most of these studies are designed and carried out by investigators associated with organizations (departments, schools, or centers) attached to universities. The principal investigators are most often faculty members engaged simultaneously in research and training of graduate students.

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[4] The health services chapter of the 1978 Report of this Committee (NRC, 1975-81) presented a cross tabulation of primary disciplines and major research problem areas to define the field. The disciplines include (p. 115): 1. Behavioral Sciences: Anthropology, Sociology, Psychology; 2. Social Sciences: Economics, Political Science; 3. Biomedical and Clinical Sciences; 4. Public Health Measurement and Analytical Sciences, Epidemiology, and Biostatistics; 5. Other Fields: Operations Research, Health Administration, Health Education, and Public Administration. The problem areas include: Health Personnel, Mental Health Personnel, Ambulatory Care, Child Health Services, Dental Health Services, Emergency Health Services, Indian Health Services, Long-term Care, Nursing Health Services, Pharmacy-related Health Services, Rural Health Care Services, Mental Health Services, Drug Abuse Prevention Programs, Alcoholism Prevention Programs, Access and Equity of Health Services, Inflation and Cost Containment, Health Insurance, Quality Assurance, Legal Aspects of Health Care, Health Politics, Community Studies, Health Education, Sociobehavioral Aspects of Health Care, Health Services Design and Development (including technology transfer).

At the other end of the spectrum are very large numbers of relatively small inquiries whose purpose is to make specific institutions more efficient. This can be called managerial research. It is in a sense more practical than the more widely applicable investigations because it has tangible, immediate effects. Some of this research is carried out by investigators associated with such operating organizations as hospitals, clinics, health maintenance organizations, state planning organizations, and federal agencies.

For this report, the entire spectrum is included in health services research. However, as will be pointed out later, the demand and supply situation in the two categories appears to be somewhat different.

THE SUPPLY OF INVESTIGATORS

Who Is a Health Services Researcher?

The diversity of health services research requires investigators with diverse backgrounds and diverse specialized training. A competent principal investigator in health services research must have two sets of qualifications. The first is an adequate grasp of a discipline or profession, such as those listed in Footnote 4, at the undergraduate, masters, or doctoral level.

The second set of qualifications is an understanding of some aspects of the delivery and financing of health care and a mastery of suitable research methods. Included are such areas as quantitative measurement of access to health care by various socioeconomic groups, means of assessing the quality of health care, medical care ethics and the law, the technical aspects of cost reimbursement, the politics of health care, management of health care delivery organizations and the administration of prepayment and health insurance plans. This training, it should be noted, is not disciplinary although a substantial portion of the students who train for health services research are awarded degrees by disciplinary departments just as in the case of biomedical and clinical sciences. These arrangements further complicate the task of counting the number of investigators capable of conducting health services research.

Because of the increasing complexity of the field, it is becoming progressively more difficult for those trained in specific disciplines or professions to conduct health services research without additional formal training to provide the second set of qualifications. University-based investigators (plus a few investigators associated with other institutions which conduct research and related advance training) provide most of the additional HSR training. Part of this training is given in courses. However, most of it is derived from seminars, discussions with other students and faculty, field work, and, most important, preparation of a dissertation. Most of these activities are conducted within centers for health services research.

Their prime contribution, realized more fully in some centers than in others, is to provide an environment in which direct, first-hand experience with, and exposure to, the health care delivery system is combined with organized study of health services issues, research problems and appropriate research methods. These are combined at the highest level in the production of the doctoral dissertation, which is the most significant event in the training of new investigators.

This evolution of educational patterns towards specialized HSR training added to earlier disciplinary training has produced two kinds of health service researchers. "One, principal investigators, is older, almost exclusively men (91 percent) and is comprised of a large number of medical degree holders (36.8 percent) as well as research doctorate holders (41.3 percent). The second group, former trainees, is younger, includes more women (46 percent), and is comprised predominantly of research doctorate holders (68.4 percent) with a much smaller portion of medical doctorates (9.4 percent) (Ebert-Flattau and Perkoff, 1983)."

Finally, a distinction must be drawn between the training required to plan and execute the "policy" and the "managerial" research discussed above in the definition of HSR. The annual number of investigators produced at the doctoral level whose area of expertise is HSR is relatively small.

Most of the managerial research is carried out by investigators with masters degrees. The annual number entering the field at the master's level is large relative to the number of Ph.D.s.

The Number of Investigators

The most comprehensive effort to estimate the number of active researchers in HSR fields was a 1978 survey conducted by this Committee which found the following:

> "Over 1,370 individuals have been identified thus far as once having received support from the NCHSR as principal investigators on health services research grants or contracts or as having received federal funds from the NCHSR or ADAMHA to train in health services research." (NRC, 1975-81, 1978 Report, p. 120)

The 1,370 figure includes some trainees who did not develop into investigators, and it excludes some investigators whose work was not federally supported. With the reservation that the figure is imprecise, 1,370 is taken for this report as a reasonable estimate of the number of health services researchers in 1977. As a point of comparison, in 1977 there were 31,000 biomedical science Ph.D.s (excluding postdoctoral appointees) in academic employment (NRC, 1975-81, 1981 Report, p. 58) and about 9,800 M.D.s primarily engaged in research (ibid., p. 39). The health services investigators thus comprise 3.4 percent of all bioscience investigators.

By 1979, there were 14,515 M.D.s primarily engaged in research and 33,980 biomedical Ph.D.s in academic employment (ibid., p. 58) for a

total of 48,495. We believe that the number of health services researchers has fallen relative to other fields, but this cannot be verified at present. If we assume that the number of health services investigators remained at 3.4 percent of the combined number of biomedical and clinical investigators, we derive a rough estimate of about 1,650 active investigators in health services research in 1979.

The 600 members of the Committee on Health Service Research of the Medical Care Section of the American Public Health Association provide a reasonable lower limit on the number of investigators. A fair approximation of the number of active investigators is about midway between 1,650 and 600, or about 1,100. This includes both junior and senior scientists with a masters degree, a Ph.D. degree, or an M.D. degree.

Unless there is a sudden increase in the demand for HSR investigators, the annual number of new entrants needed to sustain the current stock is not large. These new entrants will be from a very large pool of persons in related disciplines who have an M.S., M.P.H., Dr.Ph., Ph.D., or M.D. degree. The central problem in training health services investigators is not the supply of persons capable of being trained for this sort of research but rather attracting candidates of high quality, securing faculty positions for them, and securing funds for the research that is an essential part of advanced training. It should be emphasized that the Committee was unable to find sufficient data to better estimate the current supply of health services researchers, much less to develop reasonable quantitative estimates of future demand. In this sense the situation in health services research is very different from the biomedical, behavioral, and clinical sciences discussed earlier.

Support of Graduate and Postdoctoral Students

Graduate and postdoctoral students trained to perform health services research are the next generation of principal investigators. The number of students in the field, and to some extent the quality of the students, depend to a degree upon the availability of funds to finance their graduate work.

Federal Support

This Committee has in past reports recommended a modest program for graduate training in HSR under the NRSA authority. Nevertheless, federal traineeships and fellowships for graduate students in health services research have virtually disappeared. From a total of 406 fellowships and traineeships in 1975, there was a drop to 176 (174 traineeships and 2 fellowships) in 1980 and to zero in 1981. Even so, there is reason to believe that some training support in health services research is currently being provided by the NIH and ADAMHA. But because of difficulties with definitions, taxonomy, and the like, such training is not identified by the agencies as being in the category of HSR. Furthermore, this training is narrowly confined to

the special interests of particular Institutes within these agencies. But health services problems tend to be quite broad. We believe that training in HSR should be correspondingly broad and should extend beyond the interests of individual Institutes. Thus, as noted in Chapter 1, we have recommended a continuation of NRSA training awards in HSR through 1987.

Nonfederal Sources

Few fellowships are available from university sources for graduate students training for health services research. A small proportion of the graduate students have jobs as teaching or research assistants. It follows that most graduate students in the field are self-supported with funds derived from their own or their spouses wages or savings, loans, or in relatively rare instances, family support. These observations are based upon the impressions of program directors since no survey of sources of support for graduate students in this field has been conducted.

DEMAND FOR HEALTH SERVICES RESEARCHERS

The demand for investigators in health services research is derived from the funding of such research by public and private organizations. In measuring this demand, a distinction must be drawn between "need" in the sense of staff required to conduct what may be considered a desirable level of investigation and "demand" in the sense of jobs that must be filled if research actually funded is in progress. Some may feel that the country would benefit highly from a more intensive health services research program in all of the areas described above. In this sense, the country "needs" more health services research and if this need were met the country would require more trained investigators for health services research. In its discussion of long-term considerations later in this chapter, the Committee has adopted a "needs" approach on the grounds that there will be both wider recognition of dependence on expanded health services research and that increased resources will become available. However, this Committee does not believe that "need" so defined is a sound guide to forecasts of requirements for investigators over the short run. Instead, the Committee has consistently preferred to assess short-range demand in terms of positions required to carry out research that is expected to be funded under realistic assumptions.

Federal Funds

Budgeted

From the mid-1960s to the early 1970s, federal expenditures for health services research grew at an average rate of 24 percent per

year in current dollars--faster than either biomedical research or national health expenditures (NRC, 1975-81, 1976 Report, p. 60).

However, since the early 1970s, there has been a steady decrease in federal agency budgets specifically for health services research. The level was an estimated $79 million in 1972 in current dollars. By 1979 it had declined to $54 million.[5] In constant 1972 dollars, the 1979 level was only half the 1972 level. Reductions have occurred in the budgets of all federal agencies with health services research programs--the National Center for Health Services Research, the Health Care Financing Administration, the National Institutes of Health, and the Alcohol, Drug Abuse, and Mental Health Administration.

Reductions in the budget of the National Center for Health Services Research, the only entity empowered to finance health services research not linked to the operational responsibilities of an agency, have been particularly sharp. In constant 1972 dollars, the 1981 level was only 27 percent of the $60 million 1972 level. Reductions of this magnitude have affected all phases of the program of the agency. Institutional training grant support has ceased. The consequences for those centers which lost this type of support were reported by center directors (NRC, 1975-81, 1978 Report, pp. 120-122) to be reductions in enrollments and the quality of students, a greater number of part-time students, absence of travel funds to bring speakers to campus and to provide students with important off-campus experiences with local health care delivery systems, and lack of funds to buy important support services such as computer time and support staff. Some of the centers appear to have survived this loss. A major gap in knowledge about HSR training is the absence of systematic information about the current status of these centers.

Finally, NCHSR project support has been cut so sharply that there were no new NCHSR grants awarded in fiscal year 1982. This has further decreased both research opportunities and the training capability of some university centers.

The decline in federal support for health services research is attributable to such factors as the diversity of the field, the fact that performers and users of health services research have not presented a strongly unified case for the utility of the product, the absence of strong support for general health services research among the federal agencies with major health responsibilities, concentration on short rather than long-range issues, and the general downward pressure on federal expenditures.

Looking at the federal agencies as a whole, the short-run outlook is for level funding, or perhaps very modest increases, for directly budgeted HSR funds. In addition, the total federal effort is

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[5] These estimates (Gaus and Bolay, 1981, p. 280) exclude the costs of assessing the costs and benefits of demonstrations, and are therefore on the low side. Just how much of the cost of demonstrations should be considered as HSR is a matter that should be studied in greater detail.

increasingly mission oriented and operations oriented as a consequence of the sharp reductions in the budget for the NCHSR. The implications for training are that the demand for investigators trained for research which does not contribute to the solution of immediate operating problems will probably be down, with the possible exception of research on cost containment.

Project and Center Support

Grants to centers as such, leaving a substantial degree of freedom to decide priorities locally, are an attractive supplement to the investigator-initiated project grant. So far as training is concerned, the center grants provide wide latitude for designing training experiences tailored to the capacity and the needs of individual students.

Beginning in 1968, the NCHSR financed academic centers for health services research, and two nonacademic centers. The grants could be used at the discretion of the recipient for various purposes--faculty salary support, promotion of special missions such as development of health care technology, conduct of research, and development of advanced training.

The outcome of the experiment in supporting centers was mixed. In terms of producing research and qualified investigators, the centers were productive--some more so than others. However, administrative problems were encountered, most of which derived from unrealistic expectations as to what the centers could be expected to accomplish and lack of common understanding between the centers and NCHSR on goals and research priorities. As of 1982, NCHSR funding for centers had been phased out. The question of whether this mode of financing should be reinstated remains.

The largest and most stable federal support for a health services research center has been provided to the Rand Corporation by the Department of Health and Human Services. Beginning in 1971, Rand began a program of analysis designed to determine the potential effects of alternative methods of financing health care. The program has been financed at a total cost of approximately $70 million, by far the largest federal amount provided for a single health policy center. For the future, it appears that federal support for the program will diminish or be phased out. But support will be continued on a reduced scale (about $500,000 per year for 6 years) by the Pew Memorial Trust. The prospective smaller program will be more academically oriented and carried out in cooperation with the School of Public Health at UCLA.

Indirect Funds

A small but unknown fraction of the Medicaid and Medicare funds will be spent for the managerial type of health services research. These funds will provide increasing amounts for research bearing upon the operating efficiency of health care delivery organizations. There will be an effective incremental demand for persons trained for this kind of health services research. The centers which concentrate upon the training of people for such research have been successful in placing virtually all of their graduates in appropriate jobs.

Private Foundations

In 1975, the amount contributed to health services research by private foundations was $26.4 million. These private foundation grants have been sustained while the federal funds have been declining. Recently, the Pew Memorial Trust provided $12 million over a 5-year period to five university centers for training in policy-oriented research.

> "The emphasis of this program is to stimulate development of multi-disciplinary programs which will help prepare the leadership that will be needed...to resolve the many important health policy issues the nation faces.... Recognizing...that research is an important feature of advanced degree programs in most disciplines, it is hoped that research can be built into the total program, particularly in those that will be granting degrees." (Pew Memorial Trust, 1981, pp. 1-2)

The foundation funds have supported faculty salaries, curriculum development, innovative approaches to training, promotion of closer contact between industry, government, and universities, and some fellowships. The centers have been allowed to use foundation funds for research, but as an integral part of the graduate training process and not as an activity in itself. It is worth emphasizing that most research supported by foundations is not investigator-initiated and is not peer-reviewed in the same manner as NIH/ADAMHA grants for example.

State and Local Support, and Funds from Private Industry

While most state and local expenditures for health services research are derived from federal sources and are hence accounted for in direct and indirect federal expenditures, some funds are generated locally.

The rapidly growing private hospital industry has a health services research component which will probably grow as the industry expands. The same is true of private health care organizations such as Blue Cross and Blue Shield. While the volume of state, local, and industrial support for health services research has not been measured, in the judgment of the Committee it is a small part of the total.

The Employers

The demand for health services investigators is expressed by two types of employers who provide jobs. The first category consists of organizations which use health services research as a management tool. Included are hospitals and clinics (both public and private)

and health maintenance organizations, large prepaid health plans, state and local health departments and health planning agencies and some private consulting firms.

The second category consists of university-related organizations which typically combine the research and advanced teaching functions. They are, unlike most of the other organizations, both producers and employers of investigators. Included are 23 schools of public health, many medical schools, about 20 major university-based centers devoted to health services research and training, many university departments of economics and sociology, some schools of public administration, government and business administration, and a small number of private institutions, such as the Rand Corporation, which conduct advanced training as well as research.

The Importance of University-Based Centers

The prospective long-range situation calls for a training and research system operating at a stable, relatively low level and providing a sound base for future expansion. The heart of such a system is university-based health services research. The research base can be built only in a solid institutional home. Stable career opportunities must be available for those who are able and willing to devote themselves to the development of the new field. People active in research in related disciplines must be available for discussion and collaboration. Long-term research that is not necessarily related to current problems as perceived by federal agencies must be possible. The field must be developed and perpetuated by interaction between full-time professionals and advanced students.

The research base has two major components. The first is a group of outstanding, creative research leaders, found almost exclusively in university schools or departments, who function primarily as individuals with a limited number of graduate students. Their contributions have been so fundamental that a prudent research support policy would ensure that the best individual investigators should receive stable support.

A second component of the university system for health services research is a set of organized programs or centers associated in various ways with universities.[6] While some university-based health services centers are being supported in a fashion that virtually assures a high level of research and training productivity for several years into the future, this is not true of enough centers to give the nation a vigorous, healthy, stand-by system. The financial problems of virtually all universities are inhibiting their ability to provide stable institutional support for research centers of all kinds. The decline in federal funds for health services research has been

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[6] There is now no consensus as to the definition of a center. Any study of centers would have to frame a definition.

described above. Moreover, the most severe reductions have been in the area most relevant to long range requirements--i.e., research on methods and concepts, generally involving a senior investigator or a small group, and deeply involving graduate and postdoctoral students. As in the case with federal support, the funds provided by public and private health care organizations are concentrated on research related to their current operating problems.

Private foundations are giving a few university-based centers the kind of broadly defined, stable support that gives them the opportunity to concentrate on the long-range issues. However, it is unrealistic to expect the foundations to support the entire system at an appropriate level.

LONG-TERM CONSIDERATIONS

The Committee believes that the long run social and economic problems related to health care will become more acute. There may well be wider recognition of the need to provide a firmer conceptual and factual base for the inevitable debates over social goals, over the equity of access to medical care, over the quality of medical care, and over differential impacts on socioeconomic groups. Continuing increases in the costs of medical care could generate an intensified program of research on cost containment by both public and private organizations. Privately supported research may expand rapidly as rising costs of health insurance push large unions and employers to begin self-insuring on a larger scale.

It is likely, therefore, that the need for health services research will expand substantially in less than a decade. Federal agencies will have a strong tendency to stress short-term, mission-oriented research on operations and cost containment. The Committee recommends a broader agenda. Conscious attention should be paid to support research on issues of long-range importance by both the National Center for Health Services Research and the mission-oriented agencies.

Priorities in Support of Students

The demand for research will in turn generate an increased demand for well-qualified investigators. Maintenance of the quality of training, and particularly the capacity to provide broad, flexible health services research skills to health professionals (physicians, nurses, holders of M.P.H. degrees, etc.) and other professionals such as engineers and lawyers as well as to those in the social sciences, is a matter of first priority. In this connection, the Committee heartily endorses the $20,000 dissertation grants of the National Center for Health Services Research as an economical, productive contribution to sustaining the quality of doctoral programs related to health services.

The Need for Better Information on the Health Services Research System

In this report reliance on subjective estimates has been necessary in the case of such key factors as the number and characteristics of active investigators, the division of effort among various fields of health services research, and trends in national expenditures for health services research. Earlier efforts by this Committee and others to determine these facts should be supplemented by further investigations, so that data comparable to those presented in earlier chapters are made available to enable the analysis of trends in demand and supply. The recent report of the Institute of Medicine, Nursing and Nursing Education: Public Policies and Private Actions (1983), provides a useful model for the substance and procedures for such a study.

The most urgent task at the moment is to determine the status of training and research in the university-related health services centers and the outlook. There does not exist a comprehensive description and analysis of their research and training roles, how well these roles are performed, their strengths and weaknesses, their major accomplishments and problems, sources and volume of support for their research and training activities, and the outlook for the future.

Whether there is a need for special added efforts to strengthen the research and training capacity of some or all of the centers and the forms which this support might take cannot be soundly determined in the absence of such a review. Accordingly, the Committee suggests that a meeting be convened under the auspices of the National Academy of Sciences of major interested parties--such as federal officials, leading investigators, some center directors, and officials of private foundations--to explore such matters as the goals and content of a review, of strengths and weaknesses of HSR centers, the definition of a center, criteria for selecting centers for support, the structure and auspices for a study, and financing.[7]

[7] The Institute of Medicine report, Health Services Research (1979), did not discuss the roles, strengths, weaknesses and needs of the university-based health services centers.

6. Nursing Research

Problems encountered in the practice of nursing are widely varied, important to the health care system, and deserving of a national research effort. Research on these problems, which cover issues ranging from methods to alleviate anxiety and pain to improving the prospects for high-risk infants, is conducted mainly by nurses with doctoral degrees in biomedical and behavioral fields. There were about 2,500 such individuals in 1980 but only 7 percent reported research as a major activity. The numbers are increasing, but a solid core of well-trained investigators has not yet been developed to address all nursing research issues.

INTRODUCTION

The goal of nursing research is to facilitate the development of clinical nursing interventions which will improve health outcomes and contribute to the optimal delivery of care. To this end, according to the American Nurses' Association, nursing research "develops knowledge about health and the promotion of health over the full life span, care of persons with health problems and disabilities, and nursing actions to enhance the ability of individuals to respond effectively to actual or potential health problems. So defined, nursing research "complement[s] biomedical research, which is primarily concerned with causes and treatments of disease." [1]

[1] Statements of the American Nurses' Association, 1981, as quoted in IOM, 1983.

EXAMPLES OF NURSING RESEARCH

The scope of nursing research is very broad, including, for example:

- studies to reduce the complications of hospitalization and surgery (such as respiratory or circulatory problems) and factors that negatively influence recovery

- studies to improve the prospects for high risk infants and their parents (on prematurity, stress-induced complications in childbirth, child abuse, and developmental disabilities, for instance)

- studies of methods to alleviate anxiety, stress, and pain associated with illness or disability

- studies to facilitate the utilization of new technological developments in patient care (such as those concerned with nasogastric tube feeding of hospital patients and techniques for recovery and maintenance of eating and grasping abilities following stroke), (Jacox and Walike, 1975, pp. 2-5).

The Division of Nursing of the Bureau of Health Professions, Health Resources and Services Administration (DHHS) classifies nursing research into six categories: "fundamental," nursing practice, nursing profession, delivery of nursing services, nursing education, and utilization. Although research in all these categories is likely to have an impact on health outcomes or improved patient care, those with the most direct impact are fundamental and nursing practice research, which jointly accounted for the bulk of all funded studies as of the end of FY 1981 (HRSA, 1983).

The distinction between fundamental and nursing practice research is important and is regarded both by the Division of Nursing and by the nursing profession generally as central to an understanding of the nature and scope of nursing research. Fundamental research is research which addresses or focuses on the biological and/or behavioral functioning of human beings, their environments, and their social systems. It constitutes the science base from which nursing or other clinical practice theories can be developed and tested. The findings and theories developed through fundamental research constitute the pool of knowledge and theories which health practitioners and researchers of various types, including nurses, can draw upon to develop clinical intervention strategies and/or to test the effectiveness and efficiency of different practice methods (Bloch, 1981, p. 87). Examples of fundamental biological and/or behavioral research deemed relevant to the field of nursing and funded by the Division of Nursing include studies on the responses of children to pain, the perceptions of the elderly as concerns their physical functioning and health care needs, the effects of radiotherapy on cancer patients, and the effects of caffeine on pregnancy outcomes.

Nursing practice research, on the other hand, specifically addresses issues related to the practice of nursing as a profession--with nursing interventions, procedures, techniques, and/or methods of patient care being the focus of inquiry. Research designs used in practice research are typically experimental, explicitly postulating and testing the linkages between one or more nursing interventions, procedures, or processes and patient outcomes in controlled experiments. The processes, procedures, techniques, or interventions which are "tested" may be technical, physical, verbal, cognitive, psychosocial, and/or interpersonal. Practice research funded by the Division of Nursing has included studies on endotracheal aspiration of critically ill patients, nurse attention to psychological distress among medical-surgical patients, the effect of nurse empathy on patients, the stress of radiation treatment for cancer patients, and the effectiveness of prenatal care provided to Navajo women, among many others.

While nursing research ultimately aims at improving patient care for persons with existing health impairments and reducing or preventing health-related problems for others, some nursing research explicitly addresses, or has implications for, the relative costs of different types of interventions, procedures, settings, and providers of care--that is, for cost-effective patient care. Fagin (Am. J. Nursing, Dec. 1982), for example, reviews a number of studies conducted over the past 10 years which demonstrate that innovations in nursing practice and alternative methods of service delivery, treatment, and care can provide equivalent or superior patient outcomes at cost savings over more traditional or usual methods. Reducing hospital length of stay, preventing rehospitalization, reducing the number of outpatient visits, and reducing absenteeism have been among the cost savings demonstrated by some of these studies. Long- or short-term nursing intervention with mothers having a history of child abuse, for example, was found to result in a lower rate of child rehospitalization due to parental abuse or neglect; the addition of a nurse practitioner to a small industrial company's health service was found to reduce employee time lost from work; and patient education programs and educational counseling of patients with a variety of surgical or medical problems have been found to reduce hospital length of stay, hospital readmission rates, the number of outpatient visits, and so forth, compared to control groups not receiving such nursing interventions.

Home care as an alternative to hospitalization was the focus of a number of the studies Fagin reviewed, and all indicated potential or actual savings of home care over hospitalization. For example, training patients to administer intravenous antibiotics at home reduced hospitalization time and treatment expense. Likewise, the mean cost of home care for children dying of cancer with care coordinated by nurses and provided by parents (and physicians serving as consultants) was 18 times less expensive than that provided in a hospital setting for similar children.

FUTURE NURSING RESEARCH AGENDA

The Commission on Nursing Research of the American Nurses' Association suggests an agenda for the 1980s that would give priority to research that will generate knowledge "to guide practice" in the following broad areas:

- promoting health and well-being, as well as competency for personal care and personal health, among all age groups (including identification of the determinants of wellness and health functioning in individuals and families)
- decreasing the negative impact of health problems on coping abilities, productivity, and life satisfaction of individuals and families
- designing and developing cost-effective health care systems in meeting the nursing needs of the population
- ensuring that the nursing care needs of "vulnerable groups" (including but not limited to racial and ethnic minorities and underserved populations, such as the elderly, the mentally ill, and the poor) are met (Nursing Research, 1980).

THE SUPPLY OF RESEARCH PERSONNEL AND DEMAND FOR NURSES WITH DOCTORATES

Nursing research is conducted by investigators trained in numerous disciplines, including general medicine, various medical specialties, various branches of biomedical research, and the behavioral sciences. This diffusion of investigators makes it hard to accurately estimate the number of investigators performing nursing research. However, most nursing research funded by the Division of Nursing, HRSA, is being conducted by nurses, of whom the vast majority have doctorates in nursing or other disciplines.[2] This report therefore focuses on the supply of nurses with doctorates.

The evolution of nursing from a nonacademic discipline relying on apprentice-type training to a recognized profession with its own academic credentials and body of research has been slow, and is still progressing. Until the early 1970s the majority of new Registered

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[2] An informal review of principal investigators awarded research grants by the Division of Nursing in HRSA revealed that through the 1960s nurses with masters degrees were awarded grants. Since the early 1970s most principal investigators of funded projects have doctorates.

Nurses (RNs) were trained in hospital-based nursing schools that conferred diplomas and prepared students for Registered Nurse licensure. By 1981 that mode of preparation had fallen to less than 20 percent. Almost half of newly licensed RNs in 1981 were prepared in associate degree programs (usually in community colleges) and one-third were prepared in baccalaureate programs in 4-year colleges and universities (IOM, 1983, p. 55). Although diploma prepared RNs are declining both as a proportion of new RNs and in absolute numbers, in 1980 they still represented half the supply of employed RNs. Nurses trained in associate degree programs represented 20 percent and RNs with baccalaureate or higher degrees represented 29 percent (IOM, 1983, p. 77). This last group, numbering 364,400 nurses, is the actual and potential pool of nurse researchers since graduates of diploma and associate degree programs are not eligible for advanced degrees unless they upgrade their educational level[3].

Number of Nurses with Doctorate Degrees

The most comprehensive and most recent study of nurses with doctoral degrees was conducted by the American Nurses' Association (1981). The study estimated that approximately 2,500 (0.15 percent of 1.66 million licensed RNs) held doctoral degrees in 1980.[4] However, although the number is still relatively small, it is increasing rapidly. Between 1963 and 1969 only about 30 nurses earned doctorates each year (ANA, 1981, p. 14). Today that figure is closer to 150 (NLN, 1981, Tables 72 and 73).

There has also been a radical change in the education of nurses with doctorates. The ANA study identified 17 different doctoral degrees obtained by nurses. Up to 1965 the most frequently earned degree was the Ed.D., which was succeeded by the Ph.D. in the 1970s. The professional nursing degree (DNS) was first awarded in the 1960s and has become increasingly represented in new doctoral degrees (ANA, 1981, p. 30). The increase in nursing doctoral degrees has been paralleled by an increase in the number of doctoral programs in nursing education departments--22 in 1981-82 compared to 2 in 1959-60 (NLN, 1983).

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[3] It should be noted that a significant number of nurses advance through the educational system. Thirty-five percent of nurses with baccalaureates and half of the nurses with graduate degrees initially prepared for RN licensure in associate degree or diploma programs.

[4] Health Resources and Services Administration estimated the number of nurses with doctorates to be 4,100 in 1980 (U.S. Department of Health and Human Services, 1982, Table 3). Although this is substantially higher than the ANA estimates it still represents only 0.25 percent of licensed RNs.

Time Spent in Research

However, not all nurses with doctorates are engaged in research activities. Table 6.1 shows that 75 percent of nurses with doctorates are employed in schools of nursing (largely those that offer baccalaureate and higher degrees). Not surprisingly, the amount of time spent in research varies according to the type and place of employment, but overall fewer than 7 percent of the nurses surveyed reported research as a major function (ANA, 1981, p. 44). Table 6.1 also shows that the nurses employed in nursing schools spend, on average, less time on research than nurses in some other settings--for example, other health professional schools. Since most nurses with doctorates work in schools of nursing, this is of concern to those attempting to generate increased nursing research.

In 1970, an evaluation of a program designed to encourage faculty research noted that deans and directors of programs found it difficult to free faculty for research, and questioned how much could be expected from faculty in terms of a combined teaching and research load (Abdellah, 1970).

TABLE 6.1 Average Percent of Time Spent in Research by Work Setting and Percent of Nurses with Doctorates, 1980

Setting	% Time in Research	% of Nurses with Doctorates
School of Nursing (Baccalaur. and Higher)	11.8	70.1
School of Nursing (Hospital)	0.8	
School of Nursing (Associate Degree)	2.3	4.6
Other Health Professional School	28.4	
Other Department or School	11.1	7.1
Hospital in Service	11.5	
Hospital Nursing Admin. Work	12.3	2.9
Public/Community Health Agency	4.0	
Federal/State/Local Government	20.6	6.0
Other	14.3	9.3
		100.0

SOURCE: American Nurses' Association (1981).

A comment of this sort indicates that research activity may have been regarded as a secondary activity for faculty in nursing schools. In the intervening decade, however, there has been a radical change. More recent data suggest that the expansion of nursing education has increased the demand for doctorally prepared faculty. A survey of 58 graduate nursing programs in 40 states found a need for 1,080 faculty with doctorates in the next 5 years. The survey found that the greatest need was for faculty with preparation that emphasized research and nursing theory development (McElmurry, et al., 1982, pp. 5-10).

The Institute of Medicine in 1983 estimated that 5,800 nurses with doctorates would be working by the end of 1990--3,000 with doctorates from nursing programs and 2,800 with doctorates in other fields (IOM, 1983, p. 144). This represents an increase of 2,800 nurses with doctorates from the 1980 estimate of 3,000--probably just enough to fill the demand in the 40 states mentioned earlier, but far less than the 1990 projection of need for 14,000 doctorally prepared nurses made by the Health Resources and Services Administration, Division of Nursing (IOM, 1983, p. 145). The U.S. Department of Health and Human Services based its projections of the need for doctorally prepared nurses on the judgment-of-need criteria developed by the Western Interstate Commission on Higher Education. A national panel of expert consultants was convened to establish criteria for staffing patterns and the educational preparation of RNs to meet service needs in different health care settings (hospitals, nursing homes, home care, etc.) and in units within those settings (E.R., newborn units, etc.). If this estimate of demand is even approximately accurate, nurses with doctorates should have no problem finding employment for the next decade at least.

The Infrastructure for Research

A simple enumeration of the number of people qualified to conduct research and the amount of time spent in that activity does not encompass all the important variables that affect the amount of research being conducted. One of these is research funding, which will be discussed later. Another, which is a prerequisite for research, can be described as the infrastructure--the elements that need to be in place before a research area can become established and grow. For nursing research some of the infrastructure is still in the process of development. In 1977 this Committee noted that "even today there are less than 2,000 registered nurses who have completed doctoral education, scarcely more than an average of one doctorally trained nurse for each school of nursing in the United States" (NRC, 1975-81, 1977 Report, p. 156). By 1980 only 7 percent of full-time nurse-faculty held doctoral degrees (NLN, 1982, p. 94). This compares unfavorably with other disciplines. Well over 50 percent of the faculty of 20 schools of public health held doctorates and more than 90 percent of faculty held doctorates in schools offering doctoral and other degrees in departments of psychology, physical sciences,

biological sciences, mathematical and social sciences, and engineering (IOM, 1983, p. 136).

The relative scarcity of doctorally prepared faculty in nursing schools is likely to have several effects. First, nurses with new doctorates can find ready employment in schools of nursing and are less likely to pursue pure research careers where funding is hard to obtain. Second, as mentioned earlier, nursing school faculty with doctorates are likely to be heavily engaged in teaching and administration at the expense of research, and third, nurses being educated by faculty who do not have the research degree and are not primarily engaged in research do not have role models who might lead them to research careers. Finally, as this Committee noted in 1981, the rapid growth of doctoral training programs (which the data suggest has outstripped the growth in supply of doctorally prepared faculty) has resulted in programs of less than optimal quality (NRC, 1981).[5] In short, nursing research still lacks the solid core of research trained and oriented teachers that are vital to any area of research.

Funds for Nursing Research

The Division of Nursing, HRSA, provided about $5 million annually in funds targeted to nursing research. In 1982 this dropped to close to $3.5 million. The Institute of Medicine in its 1983 study said that this "is not a level of visibility and scientific prestige to encourage scientifically oriented RNs to pursue careers devoted to research... (IOM, 1983, p. 19)." The same report notes that "A substantial share of the health care dollar is expended on direct nursing care..." and that "Despite the fact that nurses represent the largest single group of professionals in the providing of health services to the people of this country, there is a remarkable dearth of research in nursing practice" (IOM, 1983, pp. 216-217). In a stronger statement the study says that "Research in nursing has been handicapped by inadequate levels of support" and contrasts the $5 million annually for nursing research with $1.7 billion for biomedical research between 1976 and 1981, and with dental research which receives five times as much as nursing research (IOM, 1983, p. 137). The study committee suggests that "an increase on the order of $5 million per year for research could have a substantial impact in stimulating growth of capacity for research on nursing-related matters" (IOM, 1983, p. 22).

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[5] Under the Nurse Training Act (P.L. 94-63) some special funding is available to institutions with graduate nursing programs. About 90 programs receive support each year, 10 percent of them being doctoral programs. Appropriations for this Advanced Nursing Training program were at the $12 million level for 3 years, falling to $9.6 million in FY 1982.

Other federal money is available for nursing research through the National Institutes of Health, the National Institute of Mental Health, the National Center for Health Services Research, the National Science Foundation, and other agencies. How much these agencies spend for nursing research is not clear. The National Institutes of Health in 1982 made awards worth roughly $2.8 million for projects that were defined as having nursing as a primary component. However, many of these were for training or curriculum development rather than research into nursing practice, and in many cases the abstracts of projects indicated only tangential nursing interest (National Institutes of Health, 1983).

Other sources of funds include the American Nurses' Foundation, which makes small (up to $2,100) awards. The number depends on available funds--23 in 1983, 12 in 1982.

Training Grants and Fellowships

If an adequate supply of qualified individuals to educate researchers and conduct research is an essential component of the infrastructure for research, training grants are a mechanism that can help the development of that infrastructure.

The Division of Nursing, HRSA, currently administers two programs that support graduate nurse training. The largest is for Advanced Training of Professional Nurses. This program awards grants to graduate schools of nursing and schools of public health which allocate the funds to full-time graduate students. Funding for this program totaled $7 million in 1965, and increased to $13 million in 1974. Until 1977 awards were made to undergraduate as well as graduate students. Since 1977 eligibility has been confined to graduate students. In 1983 funding dropped to $9.5 million. Those funds supported approximately 3,500 students in 137 schools, with each student receiving an average of $2,715 (Buchanan, 1983).

The second program--the National Research Service Awards (NRSA)--offers pre- and postdoctoral fellowships to students in nursing and relevant disciplines and institutional grants to schools to support full-time training in research. This program has been funded at about $1 million annually for the past 5 years (see Appendix Table D2). A few additional training awards in nursing research are made by the NIH. The Division of Nursing expects to make 38-45 new awards in FY 1983 (Wood, 1983). Only three institutional awards have been made since 1977 and all were phased out in 1981.

Since 1977 this Committee has developed recommendations concerning the number of students to be supported under the NRSA authority in the area of nursing research, the distribution between pre- and post-doctoral students, and the distribution between schools of nursing and other schools and basic science and non-science departments. The general view has been that federal support for nursing research training should emphasize the improvement of programs of demonstrated capability rather than the further proliferation of nursing doctoral

programs. The Committee has also recommended that the emphasis of the fellowship programs should be on predoctoral support to increase the pool of research personnel, and provide research faculty to staff the proliferating doctoral nursing programs. In 1977 the Committee recommended that 29 percent of fellowships be awarded to students in graduate schools of nursing in 1979 and should rise to 57 percent by 1981. It was anticipated that schools of nursing would substantially increase their ability to provide research training. In the same report the Committee recommended that the proportion of fellowships in non-science departments fall from 29 percent to zero between 1979 and 1981.

Although the data are not available to show whether the recommendations concerning the training sites of students have been implemented, Table 6.2 shows the Committee's recommendations compared to actual awards where the data are available. Two points are clear from the table. First, funding has not allowed the NRSA fellowship program to reach the recommended levels of support. Second, the proportion of postdoctoral awards has remained well within the limits recommended by the Committee.

Table 6.2 shows the Committee's recommendations compared to actual awards and demonstrates that for each year funding has failed to allow the programs to reach the recommended levels of support--by substantial shortfalls. For example, in 1979 total awards were only 56 percent of the recommendations. In the following two years that proportion fell to 49 percent. In each year the shortfall in traineeships was greater than in fellowships, with traineeships reaching only 26 percent of the recommended number in 1979, compared to 65 percent for fellowships. In 1981 the gap was even wider with trainees attaining only 17 percent of the recommended level and fellowships achieving 66 percent.

TABLE 6.2 Actual and Recommended NRSA Training Awards in Nursing Research, FY 1979-81

	FY 1979			FY 1980			FY 1981		
	Total	Trainees	Fellows	Total	Trainees	Fellows	Total	Trainees	Fellows
Actual Awards									
Total	127	13	114	118	22	96	132	16	116
Predoctoral	110	4	106	108	12	96	126	12	114
Postdoctoral	17	9	8	10	10	0	6	4	2
Committee Recommendations									
Total	225	50	175	240	65	175	270	95	175
Predoctoral	193	43	150	205	55	150	230	80	150
Postdoctoral	32	7	25	35	10	25	40	15	25

SOURCE: National Research Council (1975-81).

The Institute of Medicine in its study of nursing education reviewed the programs of federal support and recommended an expansion of support of fellowships, loans, and programs at the graduate level "to assist in increasing the rate of growth in the numbers of nurses with masters and doctoral degrees in nursing and relevant disciplines" (IOM, 1983, p. 9). (It should be noted that two members of the committee made a statement of exception to the words "and relevant disciplines." They argued that nurses should have advanced education in their own discipline--nursing--for a number of reasons including preparation for leadership in nursing and to develop competencies unique to nursing.)

In view of the continued high demand for doctorally prepared nurses and the relative immaturity of the emerging field of nursing research, we agree with the general conclusions of the IOM study. There is a need to continue to promote expertise in nursing research, and financial support for graduate students is a proven mechanism for doing so. As stated in Chapter 1, the Committee reiterates its past recommendations for research training programs in nursing research under the NRSA Act and extends them through 1987.

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APPENDIX A
Clinical Sciences Data

APPENDIX A (cont'd.)
Clinical Sciences Data

APPENDIX TABLE A1 Students in U.S. Medical Schools, by Control of Institution, 1961-82[a]

Fiscal Year	All Schools: Total	All Schools: Medical Students	All Schools: Interns & Residents	All Schools: Clinical Fellows	Public Schools: Total	Public Schools: Medical Students	Public Schools: Interns & Residents	Public Schools: Clinical Fellows	Private Schools: Total	Private Schools: Medical Students	Private Schools: Interns & Residents	Private Schools: Clinical Fellows
1961	49,899	30,688	16,970	2,241	25,115	15,954	8,362	799	24,784	14,734	8,608	1,442
1962	52,014	31,077	17,362	3,575	26,412	16,211	8,237	1,964	25,602	14,866	9,125	1,611
1963	52,219	31,238	17,380	3,601	26,198	16,432	8,292	1,474	26,021	14,806	9,088	2,127
1964	54,181	32,001	17,956	4,224	27,292	17,012	8,408	1,872	26,889	14,989	9,548	2,352
1965	55,170	32,106	18,991	4,073	27,561	17,116	8,999	1,446	27,609	14,990	9,992	2,627
1966	56,101	32,482	19,950	3,669	28,610	17,406	9,959	1,245	27,491	15,076	9,991	2,424
1967	57,618	33,142	20,290	4,186	29,358	17,906	9,932	1,520	28,260	15,236	10,358	2,666
1968	61,684	34,318	22,044	5,322	32,308	18,631	11,330	2,347	29,376	15,687	10,714	2,975
1969	63,530	35,102	23,462	4,966	33,153	19,024	11,930	2,199	30,377	16,078	11,532	2,767
1970	67,795	37,978	27,003	2,804	35,309	21,082	12,848	1,379	32,476	16,896	14,155	1,425
1971	71,500	40,476	27,440	3,584	37,733	22,616	13,956	1,161	33,767	17,860	13,484	2,423
1972	81,564	43,576	31,722	6,266 b/	44,169	24,500	16,657	3,012 b/	37,395	19,076	15,065	3,254 b/
1973	86,914	47,523	33,117	6,274 b/	47,429	26,830	16,954	3,645 b/	39,485	20,693	16,163	2,629 b/
1974	91,515	50,242	35,644	5,629 c/	50,230	28,753	18,808	2,669 c/	41,285	21,489	16,836	2,960 c/
1975	95,273	54,076	36,213	4,984	51,677	30,826	19,159	1,692	43,596	23,250	17,054	3,292
1976	100,152	56,244	38,370	5,538	55,561	32,417	20,625	2,519	44,591	23,827	17,745	3,019
1977	103,061	58,266	39,431	5,364	57,364	33,932	21,141	2,291	45,697	24,334	18,290	3,073
1978	106,868	60,424	41,222	5,222	59,880	35,633	21,992	2,255	46,988	24,791	19,230	2,967
1979	112,770	62,582	44,951	5,237	64,024	37,265	24,219	2,540	48,746	25,317	20,732	2,697
1980	116,511	64,020	46,775	5,716	66,335	38,234	25,170	2,931	50,176	25,786	21,605	2,785
1981	118,283	65,412	46,577	6,294	67,091	39,425	24,628	3,038	51,192	25,987	21,949	3,256
1982	123,988	66,484	50,381	7,123	70,601	40,132	26,791	3,678	53,387	26,352	23,590	3,445

a/Figures were obtained from the Association of American Medical Colleges (1972-83, special tabulations of 4/8/82, 5/17/82, and 6/15/83). Because AAMC data were incomplete, figures for all items in 1962 and for clinical fellows in 1969 were obtained from the American Medical Association (1960-82).

b/Includes graduate students.

c/Interpolated.

APPENDIX TABLE A2 Faculty in U.S. Medical Schools, by Control of Institution, 1961-82

	Full-Time[a/]														
	All Schools			Public Schools			Private Schools			Part-Time[b/]			Volunteer[b/]		
Fiscal Year	Total	Basic Sci. Depts.	Clin. Depts.	Total	Basic Sci. Depts.	Clin. Depts.	Total	Basic Sci. Depts.	Clin. Depts.	Total	Basic Sci. Depts.	Clin. Depts.	Total	Basic Sci. Depts.	Clin. Depts.
1961	11,224	4,023	7,201	5,054	1,849	3,205	6,170	2,174	3,996	n/a	n/a	n/a	n/a	n/a	n/a
1962	12,040	4,342	7,698	5,448	2,011	3,437	6,592	2,331	4,261	n/a	n/a	n/a	n/a	n/a	n/a
1963	13,602	4,693	8,909	6,190	2,202	3,988	7,412	2,491	4,921	n/a	n/a	n/a	n/a	n/a	n/a
1964	15,015	5,541	9,474	7,099	2,705	4,390	7,916	2,832	5,084	n/a	n/a	n/a	n/a	n/a	n/a
1965	15,882	5,233	10,649	7,609	2,452	5,157	8,273	2,781	5,492	n/a	n/a	n/a	n/a	n/a	n/a
1966	17,118	5,671	11,447	8,220	2,666	5,552	8,898	3,003	5,895	n/a	n/a	n/a	n/a	n/a	n/a
1967	19,297	5,877	13,420	9,268	2,907	6,361	10,029	2,970	7,059	n/a	n/a	n/a	n/a	n/a	n/a
1968	22,293	6,639	15,654	11,066	3,364	7,702	11,227	3,275	7,952	n/a	n/a	n/a	n/a	n/a	n/a
1969	23,034	7,048	15,986	11,126	3,567	7,559	11,908	3,481	8,427	n/a	n/a	n/a	n/a	n/a	n/a
1970	24,093	7,287	16,806	11,870	3,778	8,092	12,223	3,509	8,714	n/a	n/a	n/a	n/a	n/a	n/a
1971	27,539	8,283	19,256	13,385	4,300	9,085	14,154	3,983	10,171	7,792		n/a	49,928	n/a	n/a
1972	30,170	8,714	21,456	14,588	4,642	9,946	15,582	4,072	11,510	7,403	925	6,478	56,732	3,499	53,233
1973	33,265	9,381	23,884	15,455	4,790	10,665	17,810	4,591	13,219	6,870	880	5,990	61,895	2,817	59,078
1974	34,878	9,928	24,950	16,307	5,238	11,069	18,571	4,690	13,881	7,616	793	6,823	62,115	3,946	58,169
1975	37,010	10,164	26,846	17,820	5,488	12,332	19,190	4,676	14,514	10,011	1,027	8,984	64,393	3,896	60,497
1976	39,346	10,743	28,603	19,690	5,944	13,746	19,656	4,799	14,857	7,824	800	7,024	70,453	4,405	66,048
1977	41,650	11,301	30,349	20,819	6,383	14,436	20,831	4,918	15,913	7,738	685	7,053	74,193	4,473	69,720
1978	44,358	11,736	32,622	23,240	6,766	16,474	21,118	4,970	16,148	7,268	749	6,519	78,986	4,649	74,337
1979	46,662	12,605	34,057	24,406	7,164	17,242	22,256	5,441	16,815	9,692	922	8,770	86,096	5,353	80,743
1980	49,446	12,831	36,665	26,444	7,461	18,983	23,052	5,370	17,682	9,052	919	8,133	82,635	4,876	77,759
1981	50,532	12,816	37,716	26,555	7,471	19,084	23,977	5,345	18,632	9,550	1,017	8,533	89,077	5,100	83,977
1982	53,371	13,223	40,148	27,572	7,707	19,865	25,799	5,516	20,283	10,451	1,043	9,408	93,099	5,517	87,582

a/ Figures were obtained from the Association of American Medical Colleges (1972-83, special tabulations of 4/8/82, 5/17/82, and 6/15/83). Because AAMC data were incomplete, total full-time faculty figures for 1962 were obtained from the American Medical Association (1960-82); public and private figures for 1962 were estimated by the Committee.

b/ From the American Medical Association (1960-82).

APPENDIX TABLE A3 Clinical Sciences Faculty/Student Ratio, by Control of Institution, 1963-82[a]

Fiscal Year	All Schools: Clinical Faculty (CF)	All Schools: 4-Yr. Weighted Avg. Enrollment (WS)	All Schools: Clinical Faculty/ Student Ratio (CF/WS)	Public Schools: Clinical Faculty (CF)	Public Schools: 4-Yr. Weighted Avg. Enrollment (WS)	Public Schools: Clinical Faculty/ Student Ratio (CF/WS)	Private Schools: Clinical Faculty (CF)	Private Schools: 4-Yr. Weighted Avg. Enrollment (WS)	Private Schools: Clinical Fac./ Student Ratio (CF/WS)
1963	8,909	51,209	0.174[b]	3,988	25,850	0.154[b]	4,921	25,359	0.194[b]
1964	9,474	52,091	0.182	4,390	26,271	0.167	5,084	25,820	0.197
1965	10,649	53,331	0.200	5,157	26,826	0.192	5,492	26,505	0.207
1966	11,447	54,504	0.210	5,552	27,419	0.202	5,895	27,085	0.218
1967	13,420	55,724	0.241	6,361	28,165	0.226	7,059	27,558	0.256
1968	15,654	57,382	0.273	7,702	29,301	0.263	7,952	28,081	0.283
1969	15,986	59,706	0.268	7,559	30,849	0.245	8,427	28,827	0.292
1970	16,806	62,639	0.268	8,092	32,598	0.248	8,714	30,010	0.290
1971	19,256	65,969	0.292	9,085	34,494	0.263	10,171	31,475	0.323
1972	21,456	70,611	0.304	9,946	37,234	0.267	11,510	33,376	0.345
1973	23,884	76,805	0.311	10,665	41,090	0.260	13,219	35,714	0.370
1974	24,950	83,329	0.299	11,069	45,193	0.245	13,881	38,135	0.364
1975	26,846	88,949	0.302	12,332	48,527	0.254	14,514	40,422	0.359
1976	28,603	93,440	0.306	13,746	51,134	0.269	14,857	42,306	0.351
1977	30,349	97,571	0.311	14,436	53,678	0.269	15,913	43,893	0.363
1978	32,622	101,428	0.322	16,474	56,235	0.293	16,148	45,193	0.357
1979	34,057	105,463	0.323	17,242	59,012	0.292	16,815	46,451	0.362
1980	36,665	109,808	0.334	18,983	61,918	0.307	17,682	47,890	0.369
1981	37,716	113,952	0.331	19,084	64,615	0.295	18,632	49,337	0.378
1982	40,148	117,724	0.341	19,865	66,913	0.297	20,283	50,812	0.399

a/ Faculty is defined as all full-time faculty employed in clinical science departments of U.S. medical schools. Students are defined as a 4-year weighted average of enrollments, i.e., $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = total enrollments of medical students, interns, residents, and clinical fellows. Totals may not sum due to rounding. See Appendix Table A1 for supporting data.

b/ Estimated by the Committee.

APPENDIX TABLE A4 M.D. Graduates of U.S. Medical Schools, by Control of Institution, 1961-1982

Fiscal Year	M.D. Graduates[a/]			Number of Medical Schools[b/]		
	Total	Public	Private	Total	Public	Private
1961	6,994	n/a	n/a	86	44	42
1962	7,168	n/a	n/a	86	44	42
1963	7,264	n/a	n/a	87	44	43
1964	7,336	n/a	n/a	88	45	43
1965	7,409	n/a	n/a	88	45	43
1966	7,574	n/a	n/a	91	48	43
1967	7,743	n/a	n/a	96	53	43
1968	7,973	n/a	n/a	98	54	44
1969	8,059	n/a	n/a	100	56	44
1970	8,367	n/a	n/a	102	58	44
1971	9,005	4,891	4,114	107	62	45
1972	9,558	5,295	4,263	110	64	46
1973	10,396	5,884	4,512	113	66	47
1974	11,365	6,441	4,924	113	66	47
1975	12,716	7,175	5,541	113	66	47
1976	13,634	7,534	6,100	115	68	47
1977	13,614	7,698	5,916	119	72	47
1978	14,391	8,284	6,107	123	74	49
1979	14,966	8,852	6,114	125	74	51
1980	15,135	8,840	6,295	126	75	51
1981	15,673	9,243	6,430	126	75	51
1982	15,985	9,545	6,440	127	75	52

[a/] Figures for 1961-1970 were obtained from the American Medical Association (1960-82). Figures for 1971-82 were obtained from the Association of American Medical Colleges (1972-83, special tabulations of 10/21/82 and 6/15/83).

[b/] From the Association of American Medical Colleges (1972-83, special tabulations of 10/27/82 and 6/15/83).

DIX TABLE A5 Full-Time Budgeted Vacancies on U.S. Medical School Faculties, by Control of Institution, 1961-82[a]

All Departments			Basic Science Departments			Clinical Science Departments		
Total	Public	Private	Total	Public	Private	Total	Public	Private
784	n/a	n/a	305	n/a	n/a	515	n/a	n/a
836	n/a	n/a	348	n/a	n/a	488	n/a	n/a
826	n/a	n/a	350	n/a	n/a	476	n/a	n/a
915	n/a	n/a	401	n/a	n/a	514	n/a	n/a
955	n/a	n/a	376	n/a	n/a	579	n/a	n/a
1,115	n/a	n/a	443	n/a	n/a	672	n/a	n/a
1,374	n/a	n/a	520	n/a	n/a	854	n/a	n/a
1,585	n/a	n/a	570	n/a	n/a	1,015	n/a	n/a
1,691	n/a	n/a	579	n/a	n/a	1,112	n/a	n/a
1,634	n/a	n/a	541	n/a	n/a	1,093	n/a	n/a
1,522	856	666	518	296	222	1,004	560	444
1,757	1,111	646	511	328	183	1,246	783	463
1,857	1,144	713	550	361	189	1,307	783	524
2,079	1,339	740	601	388	213	1,478	951	527
2,250	1,505	745	618	415	203	1,632	1,090	542
2,446	1,588	858	664	467	197	1,782	1,121	661
2,503	1,599	904	638	416	222	1,865	1,183	682
2,697	1,782	915	697	484	213	2,000	1,298	702
2,821	1,811	1,010	721	467	254	2,100	1,344	756
3,055	1,971	1,084	776	489	287	2,279	1,482	797
2,887	1,978	909	656	425	231	2,231	1,553	678
2,932	1,931	1,001	668	432	236	2,264	1,499	765

gures for 1961-70 were obtained from the American Medical Association (1960-82). Figures for 1971-81 obtained from the Association of American Medical Colleges (1972-83, special tabulations of 10/21/82 and 6/15/83).

APPENDIX TABLE A6 Primary Activity of Physicians in the U.S., 1963-80[a/]

Fiscal Year	Total Active [b/] N	%	Patient Care N	%	Teaching N	%	Admin. N	%	Research N	%	Other N	%	Unclassified and Unknown Address N	%
1963	263,063	100.0	246,951	93.9	8,190	3.1	3,332	1.3	3,255	1.2	n/a	-	1,335	0.5
1964	270,885	100.0	253,543	93.6	8,869	3.3	3,512	1.3	3,627	1.3	n/a	-	1,333	0.5
1965	278,809	100.0	259,418	93.0	9,794	3.5	4,057	1.5	4,306	1.5	n/a	-	1,234	0.4
1966	287,163	100.0	266,766	92.9	10,503	3.7	4,143	1.4	4,445	1.5	n/a	-	1,306	0.5
1967	295,732	100.0	274,190	92.7	11,166	3.8	4,121	1.4	4,595	1.6	n/a	-	1,660	0.6
1968 [c/]	298,401	100.0	261,722	87.7	5,051	1.7	11,715	3.9	15,441 [d/]	5.2	2,383	0.8	2,089	0.7
1969	305,047	100.0	270,737	88.8	5,149	1.7	12,107	4.0	12,375	4.1	2,598	0.9	5,865	1.9
1970	314,407	100.0	278,535	88.6	5,588	1.8	12,158	3.9	11,929	3.8	2,635	0.8	3,562	1.1
1971	325,435	100.0	287,248	88.3	5,844	1.8	12,076	3.7	10,898	3.3	2,633	0.8	6,736	2.1
1972	336,424	100.0	292,210	86.9	5,836	1.7	11,074	3.3	9,290	2.8	2,693	0.8	15,521	4.6
1973	343,755	100.0	295,257	85.9	6,183	1.8	11,959	3.5	8,332	2.4	2,636	0.8	19,388	5.6
1974	358,134	100.0	301,238	84.1	6,464	1.8	11,739	3.3	8,159	2.2	2,666	0.7	27,868	7.8
1975	372,293	100.0	311,937	83.8	6,445	1.7	11,161	3.0	7,944	2.1	2,793	0.8	32,013	8.6
1976	387,329	100.0	318,412	82.2	6,935	1.8	11,689	3.0	8,514	2.2	2,893	0.7	38,886	10.0
1977	392,913	100.0	332,393	84.6	6,673	1.7	11,954	3.0	9,786	2.5	2,813	0.7	29,296	7.5
1978	410,655	100.0	342,714	83.6	7,025	1.7	11,858	2.9	11,437	2.8	2,777	0.7	34,844	8.5
1979	426,226	100.0	356,783	83.7	7,523	1.8	12,118	2.8	14,515	3.4	2,790	0.7	32,497	7.6
1980	441,935	100.0	376,512	85.2	7,942	1.8	12,209	2.8	15,377	3.5	2,876	0.7	27,019	6.1

/From the American Medical Association (1963-81).

/Excludes temporary foreign; includes unknown address and unclassified.

/In 1968 the AMA revised its procedures for classifying physicians, making comparisons with early years extremely ifficult. One effect was to drastically reduce the Teaching category and to increase the Administration and esearch categories.

/Includes 8,029 fellows formerly included in the Patient Care category.

APPENDIX TABLE A7 R and D Expenditures in U.S. Medical Schools, by Control of Institution, 1962-82 ($ thousands)

Fiscal Year	Total R and D Expenditures						Implicit GNP Price Deflator[b/] (1972 = 100.00)	NIH Clinical Research as a % of Total Research Obligations[c/]	Estimated Clinical R and D[d/]		
	Current Dollars [a/]			1972 Dollars					1972 Dollars		
	Total	Public	Private	Total	Public	Private			Total	Public	Private
1962	208,573	85,491	123,082	295,848	121,264	174,584	70.50	12.0	35,502	14,552	20,950
1963	264,418	106,000	158,400	369,299	148,045	221,229	71.60	13.5	49,855	19,986	29,866
1964	310,412	128,710	181,702	426,977	177,043	249,934	72.70	15.0	64,047	26,556	37,490
1965	344,787	143,627	201,160	464,047	193,307	270,740	74.30	16.5	76,568	31,896	44,672
1966	377,027	155,960	221,068	490,921	203,073	287,849	76.80	18.0	88,366	36,553	51,813
1967	422,467	178,881	243,586	534,768	226,432	308,337	79.00	20.0	106,954	45,286	61,667
1968	470,958	202,440	268,518	570,167	245,085	325,082	82.60	22.5	128,288	55,144	73,143
1969	489,314	196,800	292,500	564,376	226,990	337,370	86.70	25.0	141,094	56,748	84,343
1970	498,066	205,962	292,104	544,930	225,341	319,589	91.40	28.0	152,580	63,095	89,485
1971	499,841	207,346	292,495	520,668	215,985	304,682	96.00	30.0	156,200	64,796	91,405
1972	558,120	227,638	330,482	558,120	227,638	330,482	100.00	32.0	178,598	72,844	105,754
1973	606,921	264,808	342,113	573,649	250,291	323,358	105.80	34.0	195,041	85,099	109,942
1974	657,287	300,479	356,808	566,627	259,034	307,593	116.00	34.0	192,653	88,072	104,582
1975	784,537	363,893	420,644	616,774	286,079	330,695	127.20	39.0	240,542	111,571	128,971
1976	839,170	385,857	453,313	626,714	288,168	338,546	133.90	37.0	231,884	106,622	125,262
1977	973,827	449,709	524,118	687,246	317,367	369,879	141.70	39.0	268,026	123,773	144,253
1978	1,046,121	490,029	556,092	688,011	322,281	365,730	152.05	41.0	282,085	132,135	149,949
1979	1,190,689	585,488	605,201	719,623	353,855	365,769	165.46	38.0	273,457	134,469	138,977
1980	1,352,409	677,085	675,324	762,522	381,757	380,765	177.36	39.0	297,384	148,885	148,498
1981	1,477,919	766,565	711,354	763,467	395,994	367,473	193.58	38.0	290,117	150,478	139,640
1982	1,605,585	828,954	776,631	775,083	400,171	374,912	207.15	38.0	294,532	152,065	142,467

a/Figures were obtained from the Association of American Medical Colleges (1972-83, special tabulations of 4/8/82, 5/17/82, and 6/15/83). Because AAMC data were incomplete, figures for 1963 and 1969 were obtained from the American Medical Association (1960-82). Items may not sum to totals due to rounding.

b/From the U.S. Bureau of the Census.

c/Estimates for 1962-75 were derived from data supplied by John James, Division of Research Grants, NIH. Other years were estimated by the Committee.

d/See note to this table on next page.

NOTE TO APPENDIX TABLE A7:

ESTIMATING CLINICAL RESEARCH EXPENDITURES

An estimate of the amount of support for clinical R and D in U.S. medical schools is needed in order to refine our model of demand for clinical faculty. The best data we can obtain from the AAMC are on total R and D expenditures in medical schools. This is the variable used in our demand models. Data on clinical R and D expenditures, however, are not available.

The approach taken to derive an estimate of clinical R and D expenditures in medical schools is to apply a correction factor to total R and D expenditures. A correction factor which seems appropriate is the proportion of total NIH obligations that goes to support clinical research. From 1969 to 1982, this proportion has increased by 52 percent as shown below.

Clinical Research as Percent of NIH Obligations (NIH, 1975; NSF, 1960-82)

1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
25%	28%	30%	32%	34%	34%	39%	37%	39%	41%	38%	39%	38%	38%

In the absence of any direct measurements, the above percentages offer the best available means of estimating clinical R & D expenditures in medical schools. Accordingly, they have been used to produce the data shown in Table 2.1.

There is, of course, a serious problem of defining clinical research which clouds any attempt to measure its support. The NIH estimates were derived generally from its Central Scientific Classification System (CSCS) in which each research grant is classified according to its primary field or discipline. If that discipline falls within a group identified as clinical science, then the grant is tabulated as such. All program project and center grants are identified as clinical by the NIH.

The classification of any grant is admittedly subjective. Therefore, estimates derived by this process are subject to considerable uncertainty. Other classification schemes in use at NIH would be likely to produce different estimates of clinical research from those derived from the CSCS system. But the latter have one advantage--they were produced for a series of years under a constant definition. Thus, while the absolute levels may not be very precise, the change from year to year seems to have somewhat more validity.

APPENDIX TABLE A8 Professional Service Income in U.S. Medical Schools, by Control of Institution, 1962-82 ($ thousands)

Fiscal Year	Current Dollars[a] Total	Public	Private	1972 Dollars[b] Total	Public	Private
1962	15,500	7,453	8,047	21,986	10,572	11,414
1963	16,681	8,624	8,056	23,297	12,045	11,251
1964	18,576	9,124	9,452	25,552	12,550	13,001
1965	21,840	11,534	10,305	29,394	15,524	13,869
1966	25,203	13,369	11,834	32,816	17,408	15,409
1967	30,252	16,407	13,845	38,294	20,768	17,525
1968	47,406	28,096	19,310	57,392	34,015	23,378
1969	65,304	37,600	27,700	75,322	43,368	31,949
1970	90,057	52,232	37,825	98,531	57,147	41,384
1971	115,883	68,379	47,504	120,711	71,228	49,483
1972	138,197	75,466	62,731	138,197	75,466	62,731
1973	158,984	87,763	71,221	150,268	82,952	67,317
1974	201,642	121,842	79,800	173,829	105,036	68,793
1975	305,331	168,798	136,533	240,040	132,703	107,337
1976	409,877	218,905	190,972	306,107	163,484	142,623
1977	553,664	263,965	289,699	390,730	186,285	204,445
1978	616,971	296,219	320,752	405,768	194,817	210,952
1979	729,439	361,104	368,335	440,855	218,242	222,613
1980	880,335	436,567	443,768	496,355	246,147	250,207
1981	1,026,296	500,402	525,894	530,166	258,499	271,667
1982	1,265,146	597,484	667,662	610,739	288,431	322,308

[a]This is income under control of school. An unknown amount is not under control of school and is not reported here. Figures were obtained from the Association of American Medical Colleges (1972-83, special tabulations of 4/8/82, 5/17/82, and 6/15/83). Because AAMC data were incomplete, figures for 1969 were obtained from the American Medical Association (1960-82). Items may not sum to totals due to rounding.

[b]1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--see Appendix Table A7).

APPENDIX TABLE A9 Average Clinical R and D Expenditures and Professional Service Income per U.S. Medical School, by Control of Institution, 1962-82[a] (1972 $, thousands)

Fiscal Year	Clinical R and D Expenditures: Average per School			Clinical R and D Expenditures: Number of Schools Reporting[b]			Professional Service Income: Average per School			Professional Service Income: Number of Schools Reporting[b]			Sum of Average Clinical R & D + Professional Service Income per School		
	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private
1962	413	331	499	86	44	42	733	587	951	30	18	12	1,146	918	1,450
1963	573	444	711	87	45	42	752	669	863	31	18	13	1,325	1,113	1,574
1964	745	604	893	86	44	42	824	738	929	31	17	14	1,569	1,342	1,822
1965	880	709	1,064	87	45	42	891	817	991	33	19	14	1,771	1,526	2,055
1966	993	778	1,234	89	47	42	994	967	1,027	33	18	15	1,987	1,745	2,261
1967	1,114	854	1,434	96	53	43	891	865	922	43	24	19	2,005	1,719	2,356
1968	1,323	1,003	1,742	97	55	42	1,025	1,031	1,016	56	33	23	2,348	2,034	2,758
1969	1,550	1,091	2,163	91	52	39	1,321	1,314	1,331	57	33	24	2,871	2,405	3,494
1970	1,526	1,088	2,130	100	58	42	1,388	1,361	1,427	71	42	29	2,914	2,449	3,557
1971	1,531	1,080	2,176	102	60	42	1,724	1,656	1,833	70	43	27	3,255	2,736	4,009
1972	1,734	1,235	2,404	103	59	44	1,946	1,841	2,091	71	41	30	3,680	3,076	4,495
1973	1,894	1,418	2,557	103	60	43	2,147	2,127	2,172	70	39	31	4,041	3,545	4,729
1974	1,736	1,334	2,324	111	66	45	2,381	2,283	2,548	73	46	27	4,117	3,617	4,872
1975	2,167	1,665	2,931	111	67	44	3,077	2,765	3,578	78	48	30	5,244	4,430	6,509
1976	2,070	1,591	2,784	112	67	45	3,644	3,270	4,195	84	50	34	5,714	4,861	6,979
1977	2,311	1,768	3,136	116	70	46	4,390	3,450	5,841	89	54	35	6,701	5,218	8,977
1978	2,351	1,835	3,124	120	72	48	4,363	3,479	5,701	93	56	37	6,714	5,314	8,825
1979	2,260	1,842	2,896	121	73	48	4,740	3,829	6,184	93	57	36	7,000	5,671	9,079
1980	2,458	2,012	3,160	121	74	47	5,170	4,102	6,950	96	60	36	7,628	6,114	10,110
1981	2,418	2,061	2,971	120	73	47	5,302	4,169	7,149	100	62	38	7,720	6,230	10,120
1982	2,395	2,055	2,907	123	74	49	5,930	4,652	8,058	102	62	40	8,383	6,707	10,965

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[a] See Appendix Tables A7 and A8 for supporting data.

[b] From the Association of American Medical Colleges (1972-83, special tabulations of 4/8/82, 5/17/82, and 6/15/83). Figures for 1969 were estimated by the Committee.

APPENDIX TABLE A10 Clinical R and D Expenditures + Professional Service Income in U.S. Medical Schools, by Control of Institution, 1962-82[a]
(1972 $, thousands)

Fiscal Year	Sum of Clinical R and D Expenditures + Professional Service Income: Current Dollars: Total	Public	Private	1972 Dollars: Total	Public	Private	Weighted Sum of Clinical R and D + Professional Service Income in Last 3 Years[b]: Total	Public	Private	Weighted Sum of Average Clinical R and D + Professional Service Income per School in Last 3 Years[b]: Total	Public	Private
1962	40,529	17,712	22,817	57,488	25,123	32,364						
1963	52,377	22,934	29,440	73,153	32,031	41,117						
1964	65,138	28,430	36,707	89,598	39,107	50,491	73,348	32,073	41,273	1,341	1,122	1,606
1965	78,730	35,232	43,496	105,962	47,419	58,542	89,578	39,416	50,160	1,558	1,331	1,818
1966	93,068	41,442	51,626	121,182	53,961	67,222	105,676	46,976	58,699	1,774	1,535	2,048
1967	114,745	52,183	62,562	145,247	66,055	79,193	123,393	55,349	68,044	1,938	1,684	2,233
1968	153,372	73,645	79,727	185,680	89,159	96,521	149,339	68,807	80,532	2,086	1,804	2,433
1969	187,633	86,800	100,825	216,416	100,115	116,292	183,256	86,122	97,132	2,393	2,048	2,842
1970	229,515	109,901	119,614	251,111	120,242	130,869	217,406	102,408	114,993	[illegible]	2,323	3,326
1971	265,835	130,583	135,252	276,912	136,024	140,888	248,887	119,156	129,729	[illegible],985	2,510	3,655
1972	316,795	148,310	168,485	316,795	148,310	168,485	280,432	135,150	145,282	[illegible],276	[illegible],749	4,018
1973	365,337	177,798	187,539	345,309	168,051	177,258	313,953	150,174	163,[illegible]79	[illegible],664	3,108	4,432
1974	425,120	224,005	201,115	366,482	193,108	173,375	343,474	169,380	174,[illegible]	3,969	3,446	4,706
1975	611,300	310,716	300,584	480,582	244,274	263,308	389,714	199,635	190,07[illegible]	[illegible],380	3,803	5,245
1976	720,370	361,672	358,698	537,991	270,106	267,885	[illegible]	237,940	228,469	5,080	4,335	6,217
1977	933,457	439,352	494,105	658,756	310,058	348,698	55[illegible]	273,6[illegible]6	280,194	5,844	4,842	7,361
1978	1,045,881	497,131	548,750	687,853	326,952	360,901	635,[illegible]	30[illegible]	331,545	6,457	5,153	8,440
1979	1,181,900	583,589	598,311	714,312	352,707	361,605	[illegible]	32[illegible]	[illegible]58,026	6,782	5,379	[illegible],927
1980	1,407,774	700,630	707,144	793,738	395,033	398,706	72[illegible],554	356,850	[illegible]0,704	7,086	5,693	9,273
1981	1,587,904	791,698	796,208	820,283	408,977	411,307	780,518	387,938	392,581	7,494	6,032	9,855
1982	1,875,269	912,487	962,781	905,271	440,496	464,775	834,894	413,371	421,524	7,863	6,320	10,329

[a] See Appendix Tables A7, A9, and A9 for supporting data.

[b] Computed by the formula $D_i = 1/4(S_i + 2S_{i-1} + S_{i-2})$, where D_i = a weighted average; S_i = sum of clinical R and D expenditures + professional service income in medical schools in year i.

APPENDIX TABLE A11 Indirect Costs on NIH-Sponsored Research Grants at U.S. Medical Schools, by Control of Institution, 1969-81[a]

	All Schools		Public Schools		Private Schools	
Fiscal Year	% of Direct Costs	% of Total Costs	% of Direct Costs	% of Total Costs	% of Direct Costs	% of Total Costs
1969	20.1	16.7	20.2	16.8	20.0	16.7
1970	21.6	17.7	21.5	17.7	21.6	17.8
1971	23.1	18.8	23.2	18.8	23.1	18.8
1972	25.0	20.0	23.9	19.3	26.0	20.6
1973	27.8	21.7	26.6	21.0	28.7	22.3
1974	28.3	22.0	26.1	20.7	30.1	23.1
1975	30.6	23.4	27.4	21.5	33.4	25.0
1976	33.5	25.1	29.6	22.9	36.7	26.8
1977	33.0	24.8	28.5	22.2	37.1	27.1
1978	34.3	25.6	29.1	22.5	39.1	28.1
1979	36.0	26.4	30.1	23.1	41.4	29.3
1980	37.6	27.3	30.6	23.4	44.4	30.7
1981	38.7	27.9	31.2	23.8	46.1	31.6

[a] From NIH (special tabulation, 6/7/82).

APPENDIX TABLE A12 Change in Full-Time Faculty in U.S. Medical Schools from 1968 to 1982, by Degree Type and Department[a]

	FY1968					FY1982				
Department	M.D.	M.D./ Ph.D.	Ph.D	Other	Total	M.D.	M.D./ Ph.D.	Ph.D.	Other	Total
Basic Science										
N	554	330	2,818	256	3,958	634	425	6,850	282	8,191
%	14.0	8.4	71.1	6.5	100.0	7.7	5.2	83.7	3.4	100.0
Clinical										
N	9,735	716	1,491	1,005	12,947	28,366	1,981	5,857	2,485	38,689
%	75.2	5.5	11.5	7.8	100.0	73.4	5.1	15.1	6.4	100.0
Other										
N	238	28	222	408	896	389	50	889	891	2,219
%	26.6	3.1	24.8	45.5	100.0	17.5	2.3	40.1	40.1	100.0
TOTAL										
N	10,527	1,074	4,531	1,669	17,801[b]	29,389	2,456	13,596	3,658	49,099[b]
%	59.2	6.0	25.4	9.4	100.0	59.8	5.0	27.7	7.5	100.0

[a]Data presented in this table are from AAMC (1966-83, special tabulations prepared by George Bowden, NIH, 5/11/83).

[b]These faculty counts differ from others in this report (e.g., Appendix Table A2) because different sources were used. The sources have different methods of data collection and estimation and hence produce different totals. In most cases, the differences are minor.

APPENDIX TABLE A13 Full-Time Medical School Faculty, by Degree Held and Department, 1982[a]

Department	M.D.		M.D./Ph.D.		Ph.D.		Other		Total	
	#	%	#	%	#	%	#	%	#	%
BASIC SCIENCE										
Anatomy	87	5.8	75	5.0	1,287	85.7	53	3.5	1,502	100.0
Biochemistry	64	3.6	53	3.0	1,627	91.1	43	2.4	1,787	100.0
Microbiology	111	8.1	46	3.4	1,152	84.1	61	4.5	1,370	100.0
Pharmacology	133	10.3	110	8.5	1,011	78.4	35	2.7	1,289	100.0
Physiology	147	9.2	104	6.5	1,297	81.1	52	3.3	1,600	100.0
Other	92	14.3	37	5.7	476	74.0	38	5.9	643	100.0
TOTAL	634	7.7	425	5.2	6,850	83.6	282	3.4	8,191	100.0
CLINICAL SCIENCE										
Anesthesiology	1,674	86.2	107	5.5	96	4.9	65	3.3	1,942	100.0
Dermatology	212	77.1	18	6.5	36	13.1	9	3.3	275	100.0
Family Practice	1,198	51.8	42	1.8	652	28.2	422	18.2	2,314	100.0
Internal Medicine	8,250	83.3	568	5.7	810	8.2	275	2.3	9,903	100.0
Neurology	928	72.5	96	7.5	211	16.5	45	3.5	1,280	100.0
Ob/Gyn.	1,264	76.3	84	5.1	218	13.2	90	5.4	1,656	100.0
Ophthalmology	478	64.9	43	5.8	171	23.2	44	6.0	736	100.0
Orthopedic Surgery	425	78.6	19	3.5	65	12.0	32	5.9	541	100.0
Otolaryngology	240	53.6	17	3.8	140	31.2	51	11.4	448	100.0
Pathology	1,971	60.5	296	9.1	739	22.7	249	7.7	3,255	100.0
Pediatrics	3,451	80.0	202	4.7	433	10.0	227	5.3	4,313	100.0
Physical Medicine	286	56.5	15	3.0	83	16.4	122	24.1	506	100.0
Psychiatry	2,417	55.3	133	3.0	1,364	31.2	460	10.5	4,374	100.0
Radiology	2,190	73.3	120	4.0	486	16.3	190	6.4	2,986	100.0
Surgery	3,344	81.8	221	5.4	339	8.3	185	4.5	4,089	100.0
Other	38	53.5	0	0.0	14	19.7	19	26.8	71	100.0
TOTAL	28,366	73.5	1,981	5.1	5,857	15.1	2,485	6.4	38,689	100.0
OTHER	389	17.5	50	2.3	889	40.1	891	40.1	2,219	100.0
GRAND TOTAL	29,389	59.8	2,456	5.0	13,596	27.7	3,658	7.5	49,099[b]	100.0

[a]Data presented in this table are from AAMC (1966-83, special tabulations prepared by George Bowden, NIH, 5/11/83).

[b]These faculty counts may differ from others in this report because different sources were used. The sources have different methods of data collection and estimation and hence produce different totals. In most cases, the differences are minor.

APPENDIX TABLE A14 Field of Doctorate for Full-Time Ph.D.s on Medical School Faculties, 1982[a]
(percent of department total)

	Medical School Department				
Ph.D Field	Basic	Clinical[b]	Psychiatry	Other	Total
Allied Health	0.2	3.9	0.7	6.4	1.9
Anatomy	11.5	2.2	0.4	6.4	7.0
Anesthesiology	0.0	0.0	0.0	0.1	0.01
Biochemistry	25.2	17.9	2.6	8.3	19.4
Biology	3.3	2.2	0.4	1.1	2.5
Biophysics	2.7	1.9	0.1	1.1	2.1
Bioscience, Other	1.1	0.9	0.5	0.5	0.9
Botany	0.4	0.3	0.0	0.1	0.3
Chemistry	5.6	6.2	1.2	4.3	5.3
Clinical Pathology	0.1	0.4	0.0	0.2	0.2
Ecology	0.1	0.04	0.0	0.0	0.04
Endocrinology	0.6	0.6	0.0	0.6	0.5
Engineering	0.8	4.3	0.1	2.7	2.0
Entomology	0.1	0.04	0.0	0.0	0.05
Genetics	2.1	2.1	0.4	1.1	1.9
Geriatrics	0.0	0.04	0.0	0.1	0.02
Immunology	1.6	2.0	0.0	0.5	1.5
Information Sci.	0.1	0.2	0.1	0.5	0.1
Internal Medicine	0.1	0.2	0.0	0.0	0.1
Mathematics	0.2	2.8	0.7	6.4	1.5
Microbiology	11.0	7.5	0.1	5.5	8.4
Neurobiology	0.3	0.2	0.3	0.2	0.3

		Medical School Department				
Ph.D. Field		Basic	Clinical[b]	Psychiatry	Other	Total
Neurology		0.01	0.02	0.0	0.0	0.01
Nutrition		0.2	0.7	0.0	0.9	0.4
Ob/Gyn.		0.03	0.04	0.0	0.1	0.04
Oncology		0.2	0.04	0.0	0.0	0.1
Other Medical Sci.		0.01	0.1	0.0	0.0	0.04
Other Physical Sci.		0.1	0.3	0.0	0.0	0.1
Other Social Sci.		0.6	3.6	5.8	4.9	2.4
Pathology (Nonclin.)		0.3	1.9	0.1	1.5	0.9
Pharmacology		8.5	2.7	1.5	4.7	5.7
Physical Medicine		0.0	0.02	0.0	0.0	0.01
Physics		0.9	4.8	0.2	0.7	2.1
Physiology		14.5	6.4	0.9	7.0	10.0
Psychiatry		0.0	0.05	0.2	0.0	0.02
Psychology		2.5	10.2	77.2	12.6	13.2
Public Health		0.1	1.4	0.3	0.9	0.6
Radiology		0.1	2.2	0.0	0.1	0.8
Social Work		0.0	0.2	1.6	0.3	0.3
Surgery		0.0	0.07	0.0	0.0	0.02
Zoology		3.1	1.5	0.1	1.3	2.2
Other		2.0	8.0	4.6	18.8	5.3
TOTAL	%	100.0	100.0	100.0	100.0	100.0
	N	6,850	4,493	1,364	889	13,596

a/From AAMC (1966-83, special tabulation prepared by George B len, NIH, 5/11/83).

b/Excludes departments of psychiatry.

APPENDIX TABLE A15 Paid Employment on NIH Clinical Research Grants, 1973-78[a/]
(full-time equivalent man-years of paid employment)

Fiscal Year	Degree Type: Total	M.D.	M.D./Ph.D.	Ph.D.	Other
1973					
FTE Man-Years	3,058	891	190	939	1,038
%	100.0	29.2	6.2	30.7	33.9
1974					
FTE Man-Years	3,597	1,009	202	1,236	1,149
%	100.0	28.1	5.6	34.3	32.0
1975					
FTE Man-Years	3,080	808	193	1,106	973
%	100.0	26.2	6.3	35.9	31.6
1976					
FTE Man-Years	4,001	1,016	239	1,505	1,241
%	100.0	25.4	6.0	37.6	31.0
1977					
FTE Man-Years	3,426	899	163	1,274	1,091
%	100.0	26.2	4.8	37.2	31.8
1978					
FTE Man-Years	3,596	905	207	1,330	1,154
%	100.0	25.2	5.7	37.0	32.1

[a/]From NIH (1973-78). Clinical grants are defined in this table as those involving human subjects. The Central Scientific Classification System (CSCS) of NIH was used to identify and classify these grants (Axis III, code 11).

BLE A16 Statistical Profile of Full-Time Ph.D. Faculty in Medical School Departments, 1982

	Department																	
			Clinical[a]												Other		All	
	Basic Sci.		Total Clin.		Medical		Hospital		Surgical		Psychiatry		Other Clin.		Departments		Departments	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
less than 5	744	10.9	1,117	19.1	459	21.4	225	16.0	157	16.8	275	20.2	1	7.1	130	14.6	1,991	14.6
6-10	1,242	18.1	1,311	22.4	513	24.0	300	21.4	208	22.3	286	21.0	4	28.6	173	19.5	2,726	20.1
e 11 or more	4,864	71.0	3,429	58.6	1,170	54.6	879	62.6	568	60.9	803	58.9	9	64.3	586	65.9	8,879	65.3
TOTAL	6,850	100.0	5,857	100.0	2,142	100.0	1,404	100.0	933	100.0	1,364	100.0	14	100.0	889	100.0	13,596	100.0
Professor	2,328	34.0	1,109	18.9	345	16.1	257	18.3	181	19.4	323	23.7	3	21.4	133	15.0	3,570	26.3
Assoc. Prof.	2,168	31.7	1,620	27.7	560	26.1	449	32.0	281	30.1	328	24.1	2	14.3	149	16.8	3,937	29.0
Asst. Prof.	1,995	29.1	2,552	43.6	1,002	46.8	599	42.7	380	40.7	566	41.5	5	35.7	170	19.1	4,717	34.7
Instructor	224	3.3	457	7.8	167	7.8	83	5.9	75	8.0	132	9.7	0	0.0	18	2.0	699	5.1
Other & Unk.	135	1.9	119	2.0	68	3.2	16	1.1	16	1.7	15	1.1	4	28.6	419	17.1	673	4.9
TOTAL	6,850	100.0	5,857	100.0	2,142	100.0	1,404	100.0	933	100.0	1,364	100.0	14	100.0	889	100.0	13,596	100.0
None	3,160	47.8	3,662	67.9	1,255	64.6	825	63.8	486	59.4	1,081	81.7	15	93.8	637	71.4	7,459	57.8
AL 1-2	2,116	32.0	1,109	20.6	409	21.1	309	23.9	215	26.3	175	13.2	1	6.2	175	19.6	3,400	26.4
3-4	976	14.8	431	8.0	206	10.6	101	7.8	83	10.1	41	3.1	0	0.0	57	6.4	1,464	11.4
5 or more	354	5.4	191	3.5	72	3.7	59	4.5	34	4.2	26	2.0	0	0.0	23	2.6	568	4.4
lty) TOTAL	6,606	100.0	5,393	100.0	1,942	100.0	1,294	100.0	818	100.0	1,323	100.0	16	100.0	892	100.0	12,891	100.0
Tenured	3,431	50.1	1,582	27.0	491	22.9	394	28.1	284	30.4	411	30.1	2	14.3	421	47.4	5,434	40.0
Tenure Track	1,473	21.5	1,285	21.9	518	24.2	334	23.8	192	20.6	240	17.6	1	7.1	148	16.6	2,906	21.4
No Tenure	863	12.6	1,866	31.9	725	33.8	416	29.6	280	30.0	444	32.6	1	7.1	149	16.8	2,878	21.2
Other & Unk.	1,083	15.8	1,124	19.2	408	19.0	260	18.5	177	19.0	269	19.7	10	71.4	171	19.2	403	17.4
TOTAL	6,850	100.0	5,857	100.0	2,142	100.0	1,404	100.0	933	100.0	1,364	100.0	14	100.0	889	100.0	13,596	100.0
None	321	4.7	796	13.6	228	10.6	141	10.0	63	6.8	358	26.2	6	42.9	217	24.4	1,334	9.8
Some	5,381	78.6	3,512	60.0	1,269	59.2	940	67.0	540	57.9	757	55.5	6	42.9	521	58.6	9,414	69.3
Primary	1,003	14.6	1,244	21.2	522	24.4	262	18.7	274	29.4	184	13.5	2	14.3	94	10.6	2,341	17.2
Other & Unk.	145	2.1	305	5.2	123	5.7	61	4.3	56	6.0	65	4.8	0	0.0	57	6.4	507	3.7
TOTAL	6,850	100.0	5,857	100.0	2,142	100.0	1,404	100.0	933	100.0	1,361	100.0	14	100.0	889	100.0	13,596	100.0
		Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate(%)		Rate (%)		Rate (%)
Applications[c]	3,979	58.1	2,105	35.9	1,042	48.6	252	17.9	521	55.8	270	19.8	20	142.9	151	17.0	6,235	45.9
Awards[d]	1,241	31.2	533	25.3	239	22.9	68	27.0	146	28.0	78	28.9	2	10.0	22	14.6	1,796	28.8
Approvals[e]	3,497	87.9	1,709	81.2	839	80.5	218	86.5	451	86.6	182	67.4	19	95.0	112	74.2	5,318	85.3
applications only)																		

departments are categorized as follows: Medical (dermatology, family practice, internal medicine, neurology, pediatrics); Hospital (anesthesi-
thology, physical medicine, radiology); Surgical (ob/gyn., ophthalmology, orthopedics, otolaryngology, surgery); Psychiatry; Other Clinical.
e data, Basic Science includes pathology departments.
ion rate = # applications/# faculty members.
te = # awards/# applications.
rate = # approved applications/# applications.

AAMC (1966-83, special tabulation prepared by George Bowden, NIH, 6/9/83); NRC (1979-83, special tabulation, 6/11/83).

APPENDIX TABLE A17 Statistical Profile of Full-Time M.D. Faculty in Medical School Departments, 1982[a]

		Department																	
				Clinical[b]															
		Basic Sci.		Total Clin.		Medical		Hospital		Surgical		Psychiatry		Other Clin.		Other Departments		All Departments	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
CAREER AGE (Yrs. since M.D.)	less than 5	6	0.9	1,214	4.3	621	4.4	332	5.4	180	3.1	81	3.4	0	0.0	10	2.6	1,230	4.2
	6-10	33	5.2	4,525	16.0	2,500	17.8	811	13.3	841	14.6	371	15.4	2	5.3	10	2.6	4,568	15.4
	11 or more	595	93.9	22,627	79.8	10,918	77.8	4,978	81.3	4,730	82.3	1,965	81.3	36	94.7	369	94.9	23,591	80.3
	TOTAL	634	100.0	28,366	100.0	14,03[illegible]	100.0	6,121	100.0	5,751	100.0	2,417	100.0	38	100.0	389	100.0	29,389	100.0
ACADEMIC RANK	Professor	424	66.9	8,108	28.6	3,926	28.0	1,641	26.8	1,914	33.3	618	25.6	9	23.7	84	21.6	8,616	29.3
	Assoc. Prof.	122	19.2	6,903	24.3	3,532	25.2	1,398	22.8	1,397	2[illegible].3	569	23.5	7	18.4	29	7.5	7,054	24.0
	Asst. Prof.	71	11.2	10,720	37.8	5,319	37.9	2,430	39.7	1,940	33.7	1,016	42.0	15	39.5	22	5.7	10,813	36.8
	Instructor	11	1.7	2,453	8.6	1,178	8.4	610	10.0	460	8.0	203	8.4	2	5.3	0	0.0	2,464	8.4
	Other & Unk.	6	0.9	182	0.6	84	0.6	42	0.7	40	0.7	11	0.5	5	13.2	254	65.3	442	1.5
	TOTAL	634	100.0	28,366	100.0	14,039	100.0	6,121	100.0	5,751	100.0	2,417	100.0	38	100.0	389	100.0	29,389	100.0
YEARS OF POSTDOCTORAL RESEARCH TRAINING (1981 faculty)	None	295	43.8	19,793	74.0	8,627	65.9	4,804	82.2	4,225	78.6	2,108	8[illegible].5	29	74.4	283	73.3	20,371	73.2
	1-2	189	28.1	4,652	17.4	2,899	22.2	700	11.9	847	15.9	198	8.2	8	20.5	72	18.7	4,913	17.7
	3-4	115	17.1	1,606	6.0	1,142	8.7	230	3.9	181	3.4	51	2.1	2	5.1	19	4.9	1,740	6.2
	5 or more	74	11.0	700	2.6	417	3.2	112	1.9	120	2.2	51	2.1	0	0.0	12	3.1	786	2.8
	TOTAL	673	100.0	26,751	100.0	13,0[illegible]5	100.0	5,846	100.0	5,373	100.0	2,408	100.0	39	100.0	386	100.0	27,810	100.0
TENURE STATUS	Tenured	405	63.9	8,582	30.3	4,269	30.4	1,706	27.9	1,940	33.7	665	27.5	2	5.3	211	54.2	9,198	31.3
	Tenure Track	57	9.0	6,326	22.3	3,124	22.3	1,413	23.1	1,263	22.0	526	21.8	0	0.0	30	7.7	6,413	21.8
	No Tenure	55	8.7	7,841	27.6	3,853	27.4	1,796	29.3	1,423	24.7	763	31.6	6	15.8	61	15.7	7,957	27.1
	Other & Unk.	117	18.4	5,617	19.8	2,793	19.9	1,206	19.7	1,125	19.5	463	19.2	30	79.0	87	22.4	5,821	19.9
	TOTAL	634	100.0	28,366	100.0	14,039	100.0	6,121	100.0	5,751	100.0	2,417	100.0	38	100.0	389	100.0	29,389	100.0
RESEARCH PARTICIPATION	None	60	9.5	10,432	36.8	4,665	33.2	2,538	41.5	2,044	35.5	1,158	47.9	27	71.1	228	58.6	10,720	36.5
	Some	482	76.0	15,448	54.5	7,858	56.0	3,126	51.1	3,362	58.5	1,092	45.2	10	26.3	142	36.5	16,072	54.7
	Primary	73	11.5	1,159	4.1	849	6.0	121	2.0	113	2.0	76	3.1	0	0.0	5	1.3	1,237	4.2
	Other & Unk.	19	3.0	1,327	4.7	667	4.8	336	5.5	232	[illegible]	91	3.8	1	2.6	14	3.6	3,360	4.6
	TOTAL	634	100.0	28,366	100.0	14,039	100.0	6,121	100.0	5,751	100.0	2,417	100.0	38	100.0	389	100.0	29,389	100.0
NIH/ADAMHA RESEARCH GRANT ACTIVITY[c] (Competing applications only)			Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)		Rate (%)
	Applications[d]	741	116.9	3,184	11.2	2,238	15.9	127	2.1	593	10.3	222	9.2	4	10.5	39	10.0	3,964	13.5
	Awards[e]	256	34.5	965	30.3	712	31.8	32	[illegible]	156	26.3	64	28.8	1	25.0	13	33.3	1,234	31.1
	Approvals[f]	660	89.1	2,553	80.2	1,888	84.4	102	80.3	441	74.4	119	53.6	3	75.0	36	92.3	3,249	82.0

[a]/Excludes M.D.s who also hold a Ph.D. degree.

[b]/Clinical departments are categorized as follows: Medical (dermatology, family practice, internal medicine, neurology, pediatrics); Hospital (anesthesiology, pathology, physical medicine, radiology); Surgical (ob/gyn., ophthalmology, orthopedics, otolaryngology, surgery); Psychiatry; Other Clinical.

[c]/For these data, Basic Science includes pathology departments.

[d]/Application rate = # applications/# faculty members.

[e]/Award rate = # awards/# applications.

[f]/Approval rate = # approved applications/# applications.

SOURCES: AAMC (1966-83, special tabulation prepared by George Bowden, NIH, 7/20/83); NRC (1979-83, special tabulation, 7/29/83).

APPENDIX B
Biomedical Sciences Data

APPENDIX B (cont'd.)
Biomedical Sciences Data

APPENDIX TABLE B1 Biomedical Science Enrollments in Colleges and Universities, by Control of Institution, 1960-82[a]

	Total Undergraduate and Graduate Enrollment			Estimated Undergraduate Enrollment[b]			Graduate Enrollment: Total Medical, Dental, and Biomed. Sci. Graduate			Medical and Dental[c]			Biomedical Science Graduate[d]		
Fiscal Year	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private
1960	197,419	n/a	n/a	143,037	n/a	n/a	54,382	n/a	n/a	43,665	n/a	n/a	10,717	6,516	4,201
1961	217,711	n/a	n/a	161,236	n/a	n/a	56,475	n/a	n/a	44,268	n/a	n/a	12,207	7,768	4,439
1962	241,945	n/a	n/a	183,890	n/a	n/a	58,055	n/a	n/a	44,590	n/a	n/a	13,465	8,841	4,624
1963	265,534	n/a	n/a	205,839	n/a	n/a	59,695	n/a	n/a	44,814	n/a	n/a	14,881	9,827	5,054
1964	286,169	n/a	n/a	223,002	n/a	n/a	63,167	n/a	n/a	45,692	n/a	n/a	17,475	n/a	n/a
1965	279,371	n/a	n/a	213,042	n/a	n/a	66,329	n/a	n/a	45,982	n/a	n/a	20,347	n/a	n/a
1966	301,921	n/a	n/a	231,977	n/a	n/a	69,944	n/a	n/a	46,512	n/a	n/a	23,432	n/a	n/a
1967	311,635	n/a	n/a	239,725	161,555	78,170	71,910	n/a	n/a	47,563	n/a	n/a	24,347	n/a	n/a
1968	327,940	n/a	n/a	251,170	173,606	77,564	76,770	n/a	n/a	49,273	n/a	n/a	27,497	n/a	n/a
1969	358,186	n/a	n/a	279,180	200,825	78,335	79,006	n/a	n/a	50,510	n/a	n/a	28,496	n/a	n/a
1970	384,382	n/a	n/a	299,553	220,073	79,480	84,829	n/a	n/a	53,986	n/a	n/a	30,843	n/a	n/a
1971	414,650	n/a	n/a	325,018	242,058	82,960	89,632	n/a	n/a	57,029	n/a	n/a	32,603	n/a	n/a
1972	438,671	318,900	119,771	343,587	259,492	84,095	95,084	59,408	35,676	60,881	34,369	26,512	34,203	25,039	9,164
1973	480,055	350,954	124,101	379,268	288,109	91,159	100,787	62,845	32,942	65,899	37,390	28,509	34,888	25,455	9,433
1974	510,603	376,292	134,311	404,881	309,900	94,981	105,722	66,392	39,330	69,611	40,021	29,590	36,111	26,371	9,740
1975	537,075	399,593	137,482	424,539	328,697	95,842	112,536	70,896	41,640	74,222	42,731	31,491	38,314	28,165	10,149
1976	556,279	417,055	139,223	439,946	343,184	96,762	116,333	73,872	42,461	77,011	44,949	32,062	39,322	28,923	10,399
1977	544,402	408,393	136,009	425,863	332,770	93,093	118,539	75,623	42,916	79,279	46,657	32,622	39,260	28,966	10,294
1978	532,094	396,296	135,798	406,373	316,281	90,092	125,721	80,015	45,706	81,934	48,730	33,204	43,787	31,285	12,502
1979	503,008	372,449	130,559	374,869	290,821	84,048	128,139	81,628	46,511	84,761	50,681	34,080	43,378	30,947	12,431
1980	515,707	381,872	133,835	386,236	299,434	86,802	129,471	82,438	47,033	86,502	51,830	34,672	42,969	30,608	12,361
1981	n/a	n/a	n/a	n/a	n/a	n/a	130,371	83,344	47,027	88,254	53,194	35,060	42,117	30,150	11,967
1982	n/a	n/a	n/a	n/a	n/a	n/a	130,428	83,162	47,266	89,105	53,693	35,412	41,323	29,469	11,854

[a]Biomedical science undergraduate, graduate, and dental student enrollments for Temple University and the University of Pittsburgh were counted as public; medical school enrollments were counted as private. The Association of American Medical Colleges, which provided the medical school data, was the only data source which considered those universities to be privately controlled.

[b]Estimated by the formula $U_i=(A_{i+2}/B_{i+2})C_i$, where U_i=biomedical science undergraduate enrollment in year i; A_{i+2} = biomedical science baccalaureate degrees awarded in year i+2 (excluding health professions); B_{i+2} = total baccalaureate degrees awarded in year i+2; C_i = total undergraduate degree-credit enrollment in year i (excluding first professional). Public and private estimates were based on enrollment ratios. See Appendix Tables B3 and B4 for supporting data.

[c]Medical school enrollment figures were obtained from the Association of American Medical Colleges (1972-83, special tabulations of 4/8/82, 5/17/82, and 6/15/83) and the American Medical Association (1960-82). Dental school enrollment figures were obtained from the American Dental Association (1971-83a).

[d]Figures for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-82 were obtained from the National Science Foundation (1973-83a) except for the 1979 figure which was interpolated. Because of differences in taxonomy, NSF numbers for 1978-82 total biomedical [illegible]duate students may be slightly higher than numbers that would have been obtained from the Department of Education had data been collected for [illegible]. For the year 1977, NSF reported 42,495 graduate students enrolled in the biomedical sciences; in comparison, the Department of Education reported a somewhat lower figure of 39,260 (as shown in this table).

175

200

APPENDIX TABLE B2 First-Year Graduate Enrollment in the Biomedical Sciences, 1960-82

Fiscal Year	Total First-Year Graduate Enrollment[a]	First-Year, Full-Time Graduate Enrollment in Doctorate-Granting Institutions[b]	First-Year, Full-Time Graduate Enrollment in Doctorate-Granting Departments[c]
1960	5,370	n/a	n/a
1961	6,025	n/a	n/a
1962	6,642	n/a	n/a
1963	7,137	n/a	n/a
1964	8,542	n/a	n/a
1965	10,430	n/a	n/a
1966	12,034	n/a	n/a
1967	12,511	n/a	n/a
1968	13,301	n/a	5,683 (1967-68)
1969	13,343	n/a	5,976 (1968-69)
1970	14,835	n/a	6,168 (1969-70)
1971	15,845	n/a	6,524 (1970-71)
1972	16,722	n/a	7,103 (1971-72)
1973	17,511	n/a	7,540 (1972-73)
1974	17,538	n/a	7,926 (1973-74)
1975	18,876	9,382	8,272 (1974-75)
1976	18,756	9,910	8,636 (1975-76)
1977	18,073	9,629	8,674 (1976-77)
1978	n/a	9,490	8,322 (1977-78)
1979	n/a	8,705	7,828 (1978-79)
1980	n/a	8,214	7,377 (1979-80)
1981	n/a	8,137	7,119 (1980-81)
1982	n/a	7,962	7,039 (1981-82)

a/From the U.S. Department of Education (1959-79).

b/From the National Science Foundation (1973-83a).

c/Figures represent an average of enrollments for the two years specified. Figures for 1967-74 were estimated from total first-year graduate enrollments obtained from the U.S. Department of Education (1959-79). Those for 1975-82 were obtained from the National Science Foundation (1973-83b). Within the text of this report, these numbers appear as enrollments for the fall of the previous year (i.e., the 1981-82 number shown in this table [7,039] represents fall 1980 and fall 1981 within the text).

APPENDIX TABLE B3 Biomedical Science Degrees Awarded in Colleges and Universities, by Control of Institution, and Postdoctoral Appointments in All Employment Sectors, 1960-81

	B.A. Degrees Awarded[a] (excluding first professional)			Ph.D. Degrees Awarded[b]			Postdoctoral Appointments[c]					
								Academic[d]				
Fiscal Year	Total	Public	Private	Total	Public	Private	Total	Total	Public	Private	First-Year	Nonacademic
1960	n/a	n/a	n/a	1,096	n/a	n/a	1,639	n/a	n/a	n/a	n/a	n/a
1961	15,588	n/a	n/a	1,136	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1962	16,424	n/a	n/a	1,272	n/a	n/a	1,827	n/a	n/a	n/a	n/a	n/a
1963	18,704	n/a	n/a	1,341	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1964	22,207	n/a	n/a	1,552	n/a	n/a	2,259	n/a	n/a	n/a	n/a	n/a
1965	24,612	n/a	n/a	1,753	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1966	26,336	n/a	n/a	1,961	n/a	n/a	2,570	n/a	n/a	n/a	n/a	n/a
1967	28,157	n/a	n/a	2,181	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1968	31,221	n/a	n/a	2,545	n/a	n/a	3,224	n/a	n/a	n/a	n/a	n/a
1969	34,795	20,338	14,457	2,854	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1970	36,868	22,382	14,486	3,171	n/a	n/a	3,837	n/a	n/a	n/a	n/a	n/a
1971	40,000	24,611	15,389	3,482	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1972	42,000	26,208	15,792	3,460	2,385	1,075	3,529	n/a	n/a	n/a	n/a	n/a
1973	45,000	28,236	16,764	3,520	2,466	1,054	4,393	3,520	1,992	1,526	1,555	873
1974	47,434	29,881	17,553	3,417	2,327	1,090	4,266	n/a	n/a	n/a	n/a	n/a
1975	50,493	31,841	18,652	3,515	2,401	1,114	5,484	4,466	2,596	1,870	1,625	1,018
1976	52,642	33,244	19,398	3,578	2,447	1,131	n/a	n/a	n/a	n/a	n/a	n/a
1977	51,783	32,789	18,994	3,465	2,386	1,079	6,403	5,302	2,886	2,416	1,895	1,101
1978	49,701	30,968	18,733	3,516	2,438	1,078	n/a	n/a	n/a	n/a	n/a	n/a
1979	47,717	29,241	18,476	3,644	2,466	1,178	7,419	6,114	3,622	2,492	1,908	1,305
1980	45,106	27,279	17,827	3,823	2,632	1,191	n/a	n/a	n/a	n/a	n/a	n/a
1981	41,476	24,703	16,773	3,838	2,591	1,247	8,185	6,893	4,144	2,749	2,150	1,292

a/Figures for 1961-70 and 1974-81 were obtained from the U.S. Department of Education (1948-82: special tabulations from the Higher Education General Information Survey, 3/82 and 4/82). Figures for 1971-73 were estimated by the Committee in order to remove the distortion produced in the series by a change in the survey taxonomy in 1971. Public and private figures for 1981 were estimated by the Committee. Health professions are not included.

b/From the National Research Council (1958-82). Foreign nationals who received doctorates from U.S. institutions are included.

c/Figures for 1962-70 were estimated by the Committee. Figures for 1972-81 were obtained from the National Research Council (1973-82) except for first-year academic postdocs, which were obtained from the National Research Council (1958-82). Foreign nationals who received doctorates from U.S. institutions are included.

... and private figures were adjusted by the Committee to include a small number of individuals for whom control of institution could ...etermined.

APPENDIX TABLE B4 Total Undergraduate Degree-Credit Enrollment, Total B.A. Degrees Awarded, and Ratio of Biomedical Science B.A.s to Total B.A.s, by Control of Institution, 1960-82

Fiscal Year	Total Undergraduate Degree-Credit Enrollment (thousands): Including First Professional[a]			Excluding First Professional[b]			Total B.A. Degrees Awarded[c] (excluding first professional)			Ratio of Biomed. Sci. B.A.s to Total B.A.s[d]
	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total
1960	3,402	n/a	n/a	3,334	n/a	n/a	n/a	n/a	n/a	n/a
1961	3,610	n/a	n/a	3,538	n/a	n/a	365,337	n/a	n/a	0.0427
1962	3,891	n/a	n/a	3,813	n/a	n/a	382,822	n/a	n/a	0.0429
1963	4,207	n/a	n/a	4,123	n/a	n/a	410,421	n/a	n/a	0.0456
1964	4,529	n/a	n/a	4,438	n/a	n/a	460,467	n/a	n/a	0.0482
1965	4,342	2,802	1,541	4,255	n/a	n/a	492,984	n/a	n/a	0.0499
1966	4,829	3,184	1,645	4,732	n/a	n/a	524,117	n/a	n/a	0.0502
1967	5,160	3,451	1,709	5,057	3,408	1,649	562,369	n/a	n/a	0.0501
1968	5,557	3,810	1,747	5,437	3,758	1,679	636,863	n/a	n/a	0.0490
1969	6,043	4,308	1,735	5,905	4,248	1,657	734,002	466,133	267,869	0.0474
1970	6,529	4,749	1,780	6,377	4,685	1,692	738,070	523,442	274,628	0.0462
1971	6,889	5,076	1,813	6,719	5,004	1,715	846,110	562,345	283,765	0.0473
1972	7,104	5,302	1,802	6,913	5,221	1,692	894,110	604,471	289,639	0.0470
1973	7,199	5,401	1,799	6,998	5,316	1,682	930,272	636,378	293,894	0.0484
1974	7,396	5,589	1,807	7,187	5,501	1,686	954,376	657,455	296,921	0.0497
1975	7,833	5,986	1,847	7,610	5,892	1,718	931,663	640,524	291,139	0.0542
1976	8,468	6,520	1,948	8,234	6,423	1,811	934,443	640,799	293,644	0.0563
1977	8,559	6,595	1,964	8,312	6,495	1,817	928,228	635,909	292,319	0.0558
1978	8,722	6,696	2,026	8,471	6,593	1,878	930,201	633,183	297,018	0.0534
1979	8,709	6,662	2,047	8,452	6,557	1,895	931,340	627,084	304,256	0.0512
1980	8,962	6,850	2,112	8,699	6,744	1,955	940,251	629,338	310,913	0.0480
1981	9,354	7,162	2,192	9,074	7,046	2,028	935,140	626,452	308,688	0.0444
1982	n/a	n/a	n/a	n/a	n/a	n/a	945,000	632,772	312,228	0.0444

a/Figures for 1960-64 were obtained from the U.S. Department of Education (1961-82), those for 1965-75 from the U.S. Department of Education (1973-82), and the one for 1976 from the U.S. Department of Education (1974-82). Figures for 1977-81 were obtained by subtracting enrollment for master's and doctor's degrees from total degree-credit enrollment (U.S. Department of Education, 1974-82).

b/Figures for 1960-66 were estimated at 98% of total undergraduate degree-credit enrollment (including first professional). Those for 1967-81 were obtained by subtracting first professional enrollment from total undergraduate enrollment (including first professional). First professional enrollment data for 1967-77 were obtained from the U.S. Department of Education (1959-79), data for 1978-81 from the U.S. Department of Education (1961-82).

[illegible]s for 1961-81 were obtained from the U.S. Department of Education (1948-83). The total figure for 1982 is an intermediate pro-[illegible] obtained from the U.S. Department of Education (1973-82); the public and private figures for 1982 were estimated by the Committee.

'ABLE B5 Ph.D.s Employed in the Biomedical Sciences, 1960-81[a]

Total Labor Force	Academia (excluding postdocs.)[b] Total	Public	Private	Postdoc. Appts.	Business	Gov't.	FFRDC Labs	Hospitals/ Clinics	Non-Profit	Self-Employed	Other	Unemployed and Seeking
16,067	8,194	n/a	n/a	1,639	2,799	2,360	n/a	n/a	n/a	n/a	1,046	29
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
17,862	9,140	n/a	n/a	1,827	2,831	2,886	n/a	n/a	n/a	n/a	1,129	49
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
20,930	11,300	n/a	n/a	2,259	3,212	2,866	n/a	n/a	n/a	n/a	1,255	38
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
23,870	12,870	n/a	n/a	2,570	3,691	3,370	n/a	n/a	n/a	n/a	1,304	65
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
28,962	16,122	n/a	n/a	3,224	4,212	3,829	n/a	n/a	n/a	n/a	1,470	105
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
34,151	19,181	n/a	n/a	3,837	4,832	4,284	n/a	n/a	n/a	n/a	1,771	246
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
39,931	23,087	n/a	n/a	3,529	4,866	4,225	n/a	1,464	1,150	411	935	264
43,798	24,755	16,490	8,265	4,393	5,285	3,962	1,023	1,619	1,094	515	711	441
46,791	27,128	n/a	n/a	4,266	6,171	4,869	n/a	1,721	1,265	722	326	323
50,698	28,339	18,993	9,346	5,484	6,645	4,522	995	1,950	1,221	836	188	518
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
55,167	30,390	20,693	9,697	6,403	6,918	4,567	1,040	2,296	1,544	864	335	810
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
62,590	33,687	22,812	10,875	7,419	8,461	5,075	1,078	2,727	1,854	1,197	402	690
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
69,076	36,497	23,894	12,603	8,185	9,957	5,406	1,234	2,798	2,083	1,860	225	831

for 1960-70 were estimated by the Committee. Figures for 1972-81 were obtained from the National Research Council (1973-82).
ationals who received doctorates from U.S. institutions are included.

and private figures were adjusted by the Committee to include a small number of academically employed individuals for whom
f institution could not be determined.

APPENDIX TABLE B6 Biomedical Sciences Faculty/Student Ratio, 1962-80[a]

Fiscal Year	Faculty (F)	4-Yr. Weighted Avg. Enrollment (WS)	Ph.D. Faculty/ Student Ratio (F/WS)
1962	9,140	214,441 [b]	0.0430 [b]
1963	n/a	230,378	n/a
1964	11,300	253,140	0.0446
1965	n/a	270,787	n/a
1966	12,870	283,089	0.0455
1967	n/a	293,398	n/a
1968	16,122	305,737	0.0527
1969	n/a	323,210	n/a
1970	19,181	344,711	0.0556
1971	n/a	371,288	n/a
1972	23,087	399,153	0.0578
1973	24,755	428,513	0.0578
1974	27,128	460,451	0.0589
1975	28,339	492,844	0.0575
1976	n/a	521,948	n/a
1977	30,390	540,285	0.0562
1978	n/a	545,088	n/a
1979	33,687	535,380	0.0629
1980	35,092 [b]	521,719	0.0673 [b]

[a] Faculty is defined as all Ph.D.s academically employed in the biomedical sciences (excluding postdoctoral appointments). Students are defined as a 4-year weighted average of enrollments, i.e., $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = total graduate and undergraduate enrollments in the biomedical sciences. See Appendix Table B1 for supporting data.

[b] Estimated by the Committee.

APPENDIX TABLE B7 National Expenditures for Health-Related R and D, 1960-82[a] ($ millions)

Fiscal Year	Current Dollars Total	Federal	Private Industry	Other	1972 Dollars Total	Federal	Private Industry	Other	Implicit Price Deflator[b] (1972 = 100.0)
1960	886	448	253	185	1,290	652	368	269	68.70
1961	1,087	574	312	201	1,569	828	450	290	69.30
1962	1,333	782	336	215	1,891	1,109	477	305	70.50
1963	1,526	919	375	232	2,131	1,284	524	324	71.60
1964	1,698	1,049	400	249	2,336	1,443	550	343	72.70
1965	1,890	1,174	450	266	2,544	1,580	606	358	74.30
1966	2,111	1,316	510	285	2,749	1,714	664	371	76.80
1967	2,345	1,459	580	306	2,968	1,847	734	387	79.00
1968	2,568	1,582	661	325	3,109	1,915	800	393	82.60
1969	2,785	1,674	754	357	3,212	1,931	870	412	86.70
1970	2,847	1,667	795	385	3,115	1,824	870	421	91.40
1971	3,168	1,877	860	431	3,300	1,955	896	449	96.00
1972	3,536	2,147	934	455	3,536	2,147	934	455	100.00
1973	3,750	2,225	1,048	477	3,544	2,103	991	451	105.80
1974	4,443	2,754	1,183	506	3,830	2,374	1,020	436	116.00
1975	4,701	2,832	1,319	550	3,696	2,226	1,037	432	127.20
1976	5,107	3,059	1,469	579	3,814	2,285	1,097	432	133.90
1977	5,621	3,396	1,614	611	3,967	2,397	1,139	431	141.70
1978	6,279	3,811	1,800	668	4,130	2,506	1,184	439	152.05
1979	7,128	4,321	2,093	714	4,308	2,612	1,265	432	165.46
1980	7,942	4,723	2,433	786	4,478	2,663	1,372	443	177.36
1981	8,598	4,898	2,864	836	4,442	2,530	1,479	432	193.58
1982	9,253	4,933	3,381	889	4,467	2,406	1,632	429	207.15

a/From NIH (special tabulations, 6/7/82 and 6/8/82). Figures for 1976, 1978, and 1980-82 are NIH estimates. Items may not sum to totals due to rounding.

b/From the U.S. Bureau of the Census.

APPENDIX TABLE B6 NIH Research Grant Expenditures, 1965-81[a] ($ millions)

Fiscal Year	Total NIH Research Grant Expenditures		NIH Research Grant Expenditures in U.S. Colleges and Universities					
			Current Dollars			1972 Dollars[b]		
	Current Dollars	1972 Dollars[b]	Total	Public	Private	Total	Public	Private
1965	492.1	652.3	n/a	n/a	n/a	n/a	n/a	n/a
1966	551.2	717.7	n/a	n/a	n/a	n/a	n/a	n/a
1967	618.4	782.8	n/a	n/a	n/a	n/a	n/a	n/a
1968	647.0	783.3	n/a	n/a	n/a	n/a	n/a	n/a
1969	649.1	748.7	n/a	n/a	n/a	n/a	n/a	n/a
1970	624.3	683.0	n/a	n/a	n/a	n/a	n/a	n/a
1971	699.7	728.9	n/a	n/a	n/a	n/a	n/a	n/a
1972	825.5	825.5	675.9	339.4	336.4	675.9	339.4	336.4
1973	837.5	791.6	679.8	331.9	347.9	642.5	313.7	328.8
1974	1,093.5	942.7	880.5	446.1	434.4	759.0	384.6	374.5
1975	1,141.3	897.2	923.3	467.3	456.0	725.9	367.4	358.5
1976	1,263.6	943.7	1,018.6	512.6	506.0	760.7	382.8	377.9
1977	1,417.2	1,000.1	1,138.8	573.0	565.8	803.7	404.4	399.3
1978	1,618.0	1,064.1	1,312.8	664.7	648.7	863.4	436.7	426.7
1979	1,928.6	1,166.0	1,567.6	803.0	764.6	947.4	485.3	452.1
1980	2,132.7	1,202.5	1,728.8	887.0	841.8	974.7	500.1	474.6
1981	2,302.8	1,189.6	1,867.6	957.1	910.5	964.8	494.4	470.4

a/From NIH (1966-82; special tabulations, 6/7/82 and 6/8/82). Items may not sum to totals due to rounding.

b/1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--see Appendix Table B7). Items may not sum to totals due to rounding.

APPENDIX TABLE B9 Biomedical Science R and D Expenditures in Colleges and Universities, by Control of Institution, 1960-81 ($ millions)

Fiscal Year	Current Dollars a/			1972 Dollars b/			Weighted Sum of Biomed. Sci. R and D Expend. in Last 3 Yrs. c/ (Total, 1972 Dollars)
	Total	Public	Private	Total	Public	Private	
1960	287.4	n/a	n/a	418.3	n/a	n/a	363.5
1961	339.4	n/a	n/a	489.8	n/a	n/a	422.6
1962	402.2	n/a	n/a	570.5	n/a	n/a	492.1
1963	480.9	n/a	n/a	671.7	n/a	n/a	575.6
1964	565.7	n/a	n/a	778.2	n/a	n/a	673.0
1965	638.0	n/a	n/a	858.7	n/a	n/a	771.7
1966	724.0	n/a	n/a	942.8	n/a	n/a	859.6
1967	795.0	n/a	n/a	1,006.4	n/a	n/a	937.6
1968	860.7	n/a	n/a	1,042.1	n/a	n/a	999.4
1969	917.3	n/a	n/a	1,058.0	n/a	n/a	1,037.1
1970	991.2	n/a	n/a	1,084.5	n/a	n/a	1,060.6
1971	1,054.7	n/a	n/a	1,098.7	n/a	n/a	1,081.4
1972	1,102.2	600.5	501.7	1,102.2	600.5	501.7	1,096.0
1973	1,252.9	691.2	561.8	1,184.3	653.3	531.0	1,121.9
1974	1,284.3	691.4	592.8	1,107.1	596.1	511.1	1,144.5
1975	1,517.0	825.5	691.5	1,192.6	649.0	543.6	1,147.8
1976	1,688.8	937.9	750.9	1,261.3	700.5	560.8	1,188.4
1977	1,798.2	1,002.3	795.9	1,269.0	707.3	561.7	1,246.0
1978	2,038.8	1,158.3	880.5	1,340.9	761.8	579.1	1,285.0
1979	2,227.7	1,237.3	990.4	1,346.4	747.8	598.6	1,324.3
1980	2,534.1	1,430.5	1,103.6	1,428.8	806.6	622.2	1,365.6
1981	2,892.7	1,657.8	1,235.0	1,494.3	856.4	638.0	1,424.6

a/ Figures for 1972-81 were obtained from the National Science Foundation (1975-83). The 1978 figures are NSF estimates. Figures for other years were estimated by the Committee. Items may not sum to totals due to rounding.

b/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--see Appendix Table B7). Items may not sum to totals due to rounding.

c/ Computed by the formula $1/4(R_t + 2R_{t-1} + R_{t-2})$, where R = total biomedical science R and D expenditures (1972 dollars).

PPENDIX TABLE B10 Average Biomedical Science R and D Expenditures per School in olleges and Universities, by Control of Institution, 1972-81[a] (1972 $, thousands)

iscal ear	Average R and D Expenditures			Number of Schools Reporting[b]		
	Total	Public	Private	Total	Public	Private
972	1,865	1,793	1,960	591	335	256
973	2,004	1,950	2,074	591	335	256
974	1,858	1,774	1,966	596	336	260
975	2,225	2,009	2,552	536	323	213
976	2,357	2,175	2,633	535	322	213
977	2,368	2,197	2,625	536	322	214
978	2,386	2,301	2,507	562	331	231
979	2,383	2,252	2,569	565	332	233
980	2,538	2,429	2,694	563	332	231
981	2,654	2,579	2,762	563	332	231

/ See Appendix Table B9 for supporting data.

/ From the National Science Foundation. For 1978, the number of doctorate-granting astitutions was obtained from NSF; the number of master's-granting institutions was stimated by the Committee.

PPENDIX TABLE B11 Indirect Costs on NIH-Sponsored Research Grants at Institutions of Higher ducation, 1970-81[a]

	All Institutions of Higher Ed.		Public Schools		Private Schools	
iscal ear	% of Direct Costs	% of Total Costs	% of Direct Costs	% of Total Costs	% of Direct Costs	% of Total Costs
.970	25.8	20.5	26.6	21.0	24.8	19.9
.971	27.2	21.4	28.2	22.0	26.3	20.8
.972	28.4	22.1	28.7	22.3	28.2	22.0
.973	30.3	23.3	30.4	23.3	30.4	23.3
.974	31.8	24.1	30.4	23.3	33.2	24.9
.975	32.5	24.5	30.2	23.2	34.8	25.8
.976	34.6	25.7	31.8	24.1	37.7	27.4
.977	35.1	26.0	31.4	23.9	38.9	28.0
.978	36.1	26.5	31.8	24.1	40.6	28.9
.979	37.6	27.3	32.8	24.7	42.9	30.0
1980	39.3	28.2	33.3	25.0	46.0	31.5
1981	40.4	28.8	34.2	25.5	47.7	32.3
Average Annual Growth Rate 1970-81	4.2%	3.1%	2.3%	1.8%	6.1%	4.5%

a/ From NIH (1966-82).

TABLE B12 Faculty Attrition Rates at U.S. Medical Schools, by Department and Degree Type, 1970-81[a]

	All Departments				Clinical Departments				Basic Science Departments			
	Total	M.D.s	Ph.D.s	Other	Total	M.D.s	Ph.D.s	Other	Total	M.D.s	Ph.D.s	Other
	6.3	6.5	4.6	9.6	7.1	6.8	7.3	9.7	4.8	5.1	3.3	4.3
	6.5	6.9	4.5	8.8	7.3	7.2	6.4	9.7	4.7	5.3	3.6	7.6
	7.8	7.7	6.3	12.2	8.2	7.9	7.7	11.8	6.8	6.3	5.5	12.7
	7.2	7.0	5.2	13.4	7.8	7.1	6.9	15.3	5.8	6.2	4.3	10.7
	6.5	6.4	4.9	11.1	7.0	6.6	6.7	10.9	5.3	5.3	3.9	11.4
	6.7	6.5	5.4	11.6	7.1	6.7	6.8	10.8	5.9	5.4	4.6	12.7
	7.5	7.4	5.8	13.1	8.2	7.7	7.5	13.7	6.0	5.6	4.9	12.2
	7.7	7.7	6.0	12.0	8.2	8.0	7.5	11.6	6.3	5.9	5.2	12.4
	6.5	6.6	4.9	11.0	7.1	6.8	6.5	11.3	5.2	5.1	4.1	10.4
	6.3	6.3	5.1	10.8	6.9	6.6	7.1	10.3	5.0	4.1	4.0	11.4
	5.9	6.0	4.8	8.6	6.4	6.2	5.9	9.0	4.7	4.1	4.2	8.1
	5.8	5.8	4.7	9.8	6.1	6.0	5.6	8.6	5.1	4.3	4.2	11.5
1970-81	6.7	6.7	5.2	11.0	7.3	7.0	6.8	11.0	5.5	5.2	4.3	10.4

Sherman and Bowden (1982). Based on the Medical School Faculty Roster. Figures represent percent of full-time faculty each year for retirement, death, and other reasons.

APPENDIX TABLE B13 Postdoctoral Research Training of New Faculty Hires in U.S. Medical Schools, by Department and Degree Type, 1970-81[a]

Fiscal Year	All Departments		Clinical Departments		Basic Science Departments	
	M.D.s	Ph.D.s	M.D.s	Ph.D.s	M.D.s	Ph.D.s
1970	28.2	29.6	27.7	20.1	31.7	39.2
1971	26.1	32.5	25.0	22.5	35.6	43.4
1972	25.8	39.3	24.6	28.5	36.6	49.4
1973	22.9	41.0	22.7	26.9	25.1	54.1
1974	25.0	44.2	24.3	31.0	33.9	57.3
1975	22.5	41.7	21.7	29.9	31.1	55.9
1976	23.4	49.9	22.8	37.9	30.4	62.2
1977	23.7	50.7	22.7	38.3	37.4	64.5
1978	23.5	56.0	23.2	43.8	28.4	72.7
1979	20.0	55.8	19.4	41.4	29.4	72.2
1980	22.2	55.3	21.6	38.2	30.4	71.8
1981	25.3	55.7	24.0	42.0	42.4	71.6
Average 1970-81	24.0	46.0	23.4	33.4	32.7	59.5

a/ From Sherman and Bowden (1982). Based on Medical School Faculty Roster. Figures represent percent of new full-time faculty with postdoctoral research training.

APPENDIX TABLE B14 Ph.D.s Academically Employed in the Biomedical Sciences, by Employment Status and Type of Institution, 1973-81[a]

Fiscal Year	Employment Status	Type of Institution: Total	4-Year	2-Year
1973	Total	24,755	24,236	519
	Full-Time	24,048	23,557	491
	Part-Time	707	679	28
1975	Total	28,339	27,716	623
	Full-Time	27,494	26,926	568
	Part-Time	845	790	55
1977	Total	30,390	29,610	780
	Full-Time	29,479	28,774	705
	Part-Time	911	836	75
1979	Total	33,687	32,865	822
	Full-Time	32,675	31,926	749
	Part-Time	1,012	939	73
1981	Total	36,497	35,659	838
	Full-Time	35,477	34,716	761
	Part-Time	1,020	943	77
Average Annual Growth Rate from 1973-81	Total	5.0	4.9	6.2
	Full-Time	5.0	5.0	5.6
	Part-Time	4.7	4.2	13.5

[a]From the National Research Council (1973-82). Foreign nationals who received doctorates from U.S. institutions are included. Individuals on postdoctoral appointments are excluded.

APPENDIX TABLE B15 Year Company Started Research or Development Activities Related to the New Biotechnology--Survey Results[a]

Year Started	Number of Respondents	Percentage of Respondents
Before 1970	6	5.2
1970	0	0.0
1971	2	1.7
1972	0	0.0
1973	1	0.9
1974	2	1.7
1975	8	6.8
1976	4	3.4
1977	2	1.7
1978	10	8.6
1979	14	12.1
1980	15	12.9
1981	29	25.0
1982	23	19.8
TOTAL	116	100.0

[a]From a survey of the biotechnology industry sponsored jointly by the Committee and the Congressional Office of Technology Assessment (1983).

APPENDIX TABLE B16 Number of Biomedical Ph.D.s per Firm in the Biotechnology Industry--Survey Results[a]

Number of Ph.D.s per Firm	Number of Firms Responding	Percentage of Firms Responding
0	4	3.4
1-5	47	40.5
6-10	26	22.4
11-15	15	12.9
16-20	8	6.9
21-25	5	4.3
26-30	1	0.9
31-35	5	4.3
36-40	1	0.9
over 40	4	3.4
TOTAL	116	100.0

[a]From a survey of the biotechnology industry sponsored jointly by the Committee and the Congressional Office of Technology Assessment (1983).

APPENDIX TABLE B17 Percent of the Postdoctoral Population in the Biomedical Sciences Who Had Earned Their Doctorates More Than 2, 3, or 4 Years Earlier, 1973-81[a]

		Number of Years Since Ph.D.					
		> 2 Years		>3 Years		> 4 Years	
Fiscal Year	Total Postdocs	N	%	N	%	N	%
1973	4,393	1,362	31.0	770	17.5	519	11.8
1975	5,484	1,923	35.1	1,114	20.3	843	15.4
1977	6,403	2,478	38.7	1,529	23.9	1,051	16.4
1979	7,419	2,999	40.3	2,018	27.2	1,532	20.6
1981	8,185	3,447	42.1	2,244	27.4	1,593	19.5

[a]From the National Research Council (1973-82).

APPENDIX TABLE B18 Annual Number of Biomedical Scientists in the FY 1981 Ph.D. Labor Force Expected to Reach the Age of 65 During the FY 1983-2001 Period[a]

Fiscal Year	Employment Sector: Total	Academia	Other Sectors
1983	474	260	208
1985	584	420	152
1987	744	400	340
1989	934	534	399
1991	1,102	685	406
1993	1,226	790	424
1995	1,360	826	514
1997	1,262	752	497
1999	1,436	890	530
2001	1,484	916	555

[a] From the National Research Council (1973-82).

APPENDIX C
Behavioral Sciences Data

TABLE C1 Behavioral Science Enrollments in Colleges and Universities, by Control of Institution, 1960-82a/

tal Undergraduate d Graduate Enrollment			Estimated Undergraduate Enrollment b/			Graduate Enrollment: Total Behavioral c/			Graduate Enrollment: Clinical Behavioral d/			Graduate Enrollment: Nonclinical Behavioral d/		
tal	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private
2,976	n/a	n/a	160,228	n/a	n/a	12,748	6,616	6,132	3,788	n/a	n/a	8,960	n/a	n/a
4,799	n/a	n/a	179,829	n/a	n/a	14,960	7,981	6,979	4,403	n/a	n/a	10,557	n/a	n/a
5,508	n/a	n/a	210,132	n/a	n/a	15,376	8,293	7,083	4,978	n/a	n/a	10,398	n/a	n/a
7,638	n/a	n/a	241,032	n/a	n/a	16,606	9,456	7,150	4,733	n/a	n/a	11,873	n/a	n/a
4,376	n/a	n/a	285,594	n/a	n/a	18,782	n/a	n/a	4,866	n/a	n/a	13,916	n/a	n/a
6,576	n/a	n/a	295,627	n/a	n/a	20,949	n/a	n/a	5,610	n/a	n/a	15,339	n/a	n/a
2,914	n/a	n/a	358,840	n/a	n/a	24,074	n/a	n/a	6,511	n/a	n/a	17,563	n/a	n/a
1,820	n/a	n/a	406,763	274,125	132,638	25,057	n/a	n/a	5,949	n/a	n/a	19,108	n/a	n/a
5,959	n/a	n/a	466,076	322,147	143,929	29,883	n/a	n/a	7,139	n/a	n/a	22,744	n/a	n/a
5,816	n/a	n/a	531,813	382,581	149,232	34,003	n/a	n/a	8,525	n/a	n/a	25,478	n/a	n/a
7,063	n/a	n/a	600,555	441,211	159,344	36,508	n/a	n/a	9,172	n/a	n/a	27,336	n/a	n/a
8,333	n/a	n/a	647,977	482,583	165,394	40,356	n/a	n/a	10,882	n/a	n/a	29,474	n/a	n/a
3,887	543,471	180,416	682,002	515,078	166,924	41,885	28,393	13,492	10,909	7,268	3,641	30,976	21,125	9,851
2,414	537,894	174,520	667,581	507,125	160,456	44,833	30,769	14,064	12,125	8,179	3,946	32,708	22,590	10,118
9,339	523,310	166,029	642,378	491,682	150,696	46,961	31,628	15,333	13,858	9,067	4,791	33,103	22,561	10,542
5,454	525,296	157,158	636,418	492,743	143,675	49,036	32,553	16,483	14,840	9,462	5,378	34,196	23,091	11,105
2,209	533,644	158,565	640,413	499,559	140,854	51,796	34,085	17,711	16,925	10,576	6,349	34,871	23,509	11,362
3,894	503,826	150,068	602,913	471,116	131,797	50,981	32,710	18,271	17,264	10,444	6,820	33,717	22,266	11,451
3,922	494,045	149,877	588,153	457,761	130,392	55,769	36,284	19,485	19,685	12,257	7,428	36,084	24,027	12,057
1,034	466,656	144,378	555,263	430,769	124,494	55,771	35,887	19,884	20,292	12,426	7,866	35,479	23,461	12,018
7,263	478,544	148,719	571,490	443,054	128,436	55,773	35,490	20,283	20,909	12,595	8,314	34,864	22,895	11,969
n/a	n/a	n/a	n/a	n/a	n/a	56,394	34,943	21,451	n/a	n/a	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	n/a	n/a	56,045	34,704	21,341	n/a	n/a	n/a	n/a	n/a	n/a

table, clinical behavioral fields include clinical and school psychology, counseling, and guidance; nonclinical behavioral fields include ogy, sociology, and nonclinical psychology. Numbers are lower than those presented in previous reports because speech pathology/audiology has been rom the behavioral science taxonomy. It has been determined that this field is not equivalent to the behavioral field, speech and hearing sciences.

ed by the formula $U_i=(A_{i+2}/B_{i+2})C_i$, where U_i=behavioral science undergraduate enrollment in year i; A_{i+2} = behavioral science eate degrees awarded in year i+2; B_{i+2} = total baccalaureate degrees awarded in year i+2; C_i = total undergraduate degree-credit enrollment (excluding first professional). Public and private estimates were based on enrollment ratios. See Appendix Tables C4 and C5 for supporting data.

for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-82 were obtained from the National Science (1973-83a) except for the 1979 figure, which was interpolated. Due to differences in taxonomy, NSF numbers for 1978-82 may be slightly an numbers that would have been obtained from the Department of Education had data been collected for those years. For the year 1977, NSF 54,955 graduate students enrolled in the behavioral sciences; in comparison, the Department of Education reported a somewhat lower figure of shown in this table).

aduate enrollment in clinical behavioral fields was estimated by the formula $CG_i=(CP_{i+2}/TP_{i+2})E_i$, where CG_i = clinical enrollment in year i; CP_{i+2} = clinical psychology Ph.D. degrees awarded in year i+2; TP_{i+2} = total psychology Ph.D. degrees awarded 2; E_i = psychology graduate enrollment in year i. Public and private estimates were based on enrollment ratios. Nonclinical behavioral enrollment represents the difference between total behavioral and clinical behavioral graduate enrollments. See Appendix Tables C4 and C6 for data.

PPENDIX TABLE C2 First-Year Graduate Enrollment in the Behavioral Sciences, 1960-82

iscal ear	Total First-Year Graduate Enrollment[a]	First-Year, Full-Time Graduate Enrollment in Doctorate-Granting Institutions[b]	First-Year, Full-Time Graduate Enrollment in Doctorate-Granting Departments[c]
1960	6,188	n/a	n/a
1961	7,732	n/a	n/a
1962	8,038	n/a	n/a
1963	8,739	n/a	n/a
1964	9,288	n/a	n/a
1965	11,832	n/a	n/a
1966	13,659	n/a	n/a
1967	13,659	n/a	4,191
1968	15,966	n/a	4,899
1969	16,831	n/a	5,164
1970	19,501	n/a	5,983
1971	22,709	n/a	6,968
1972	22,604	n/a	6,935
1973	23,845	n/a	7,316
1974	24,138	n/a	7,406
1975	25,081	9,508	8,017
1976	26,270	9,259	7,499
1977	24,551	9,368	7,772
1978	n/a	9,411	7,725
1979	n/a	8,381	6,883
1980	n/a	8,188	6,755
1981	n/a	8,291	6,813
1982	n/a	7,955	6,681

a/From the U.S. Department of Education (1959-79).

b/From the National Science Foundation (1973-83a).

c/Figures for 1967-74 were estimated from total first-year graduate enrollments obtained from the U.S. Department of Education (1959-79). Figures for 1975-82 were obtained from the National Science Foundation (1973-83b). Within the text of this report, these numbers appear as enrollments for the fall of the previous year.

APPENDIX TABLE C3 Behavioral Science Postdoctoral Appointments, 1962-81[a]

Fiscal Year	All Behavioral Fields: Total	All Behavioral Fields: Academic[b] Total	All Behavioral Fields: Academic[b] Public	All Behavioral Fields: Academic[b] Private	All Behavioral Fields: Nonacademic	Clinical Behavioral Fields: Total	Clinical Behavioral Fields: Academic[b] Total	Clinical Behavioral Fields: Academic[b] Public	Clinical Behavioral Fields: Academic[b] Private	Clinical Behavioral Fields: Nonacademic	Nonclinical Behavioral Fields: Total	Nonclinical Behavioral Fields: Academic[b] Total	Nonclinical Behavioral Fields: Academic[b] Public	Nonclinical Behavioral Fields: Academic[b] Private	Nonclinical Behavioral Fields: Nonacademic
1962	137	n/a	n/a	n/a	n/a	35	n/a	n/a	n/a	n/a	102	n/a	n/a	n/a	n/a
1963	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1964	209	n/a	n/a	n/a	n/a	55	n/a	n/a	n/a	n/a	154	n/a	n/a	n/a	n/a
1965	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1966	251	n/a	n/a	n/a	n/a	66	n/a	n/a	n/a	n/a	185	n/a	n/a	n/a	n/a
1967	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1968	331	n/a	n/a	n/a	n/a	80	n/a	n/a	n/a	n/a	251	n/a	n/a	n/a	n/a
1969	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1970	415	n/a	n/a	n/a	n/a	105	n/a	n/a	n/a	n/a	310	n/a	n/a	n/a	n/a
1971	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1972	513	n/a	n/a	n/a	n/a	124	n/a	n/a	n/a	n/a	389	n/a	n/a	n/a	n/a
1973	604	410	260	150	194	168	71	50	21	97	436	339	210	129	97
1974	603	n/a	n/a	n/a	n/a	216	n/a	n/a	n/a	n/a	387	n/a	n/a	n/a	n/a
1975	739	579	371	208	160	181	94	69	25	87	558	485	302	183	73
1976	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1977	1,038	760	429	331	278	384	196	101	95	188	654	564	328	236	90
1978	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1979	1,144	820	405	415	324	317	191	62	129	508	827	629	343	286	198
1980	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1981	1,016	725	407	318	291	295	175	109	66	470	721	550	298	252	171

[a]In this table, clinical behavioral fields include clinical and school psychology, counseling, and guidance; nonclinical behavioral fields include anthropology, sociology, nonclinical psychology, and speech and hearing sciences. Figures for 1962-70 were estimated by the Committee. Figures for 1972-81 were obtained from the National Research Council (1973-82). Foreign nationals who received doctorates from U.S. institutions are included.

[b]Public and private figures were adjusted by the Committee to include a small number of individuals for whom control of institution could not be determined.

APPENDIX TABLE C4 Behavioral Science Degrees Awarded in Colleges and Universities, by Control of Institution, 1961-81[a]

Fiscal Year	B.A. Degrees Awarded[b] (excluding first professional)			Ph.D. Degrees Awarded[c]								
				Total Behavioral			Clinical			Nonclinical		
	Total	Public	Private	Total	Public	Private	Total	Public	Private	Total	Public	Private
1961	16,527	n/a	n/a	1,042	n/a	n/a	381	n/a	n/a	661	n/a	n/a
1962	18,398	n/a	n/a	1,121	n/a	n/a	362	n/a	n/a	759	n/a	n/a
1963	20,862	n/a	n/a	1,184	n/a	n/a	367	n/a	n/a	817	n/a	n/a
1964	25,376	n/a	n/a	1,297	n/a	n/a	469	n/a	n/a	828	n/a	n/a
1965	28,820	n/a	n/a	1,275	n/a	n/a	398	n/a	n/a	877	n/a	n/a
1966	33,728	n/a	n/a	1,496	n/a	n/a	439	n/a	n/a	1,057	n/a	n/a
1967	39,072	n/a	n/a	1,773	n/a	n/a	529	n/a	n/a	1,244	n/a	n/a
1968	48,295	n/a	n/a	1,970	n/a	n/a	613	n/a	n/a	1,357	n/a	n/a
1969	59,040	33,534	25,506	2,408	n/a	n/a	666	n/a	n/a	1,742		
1970	68,413	40,533	27,880	2,726	n/a	n/a	707	n/a	n/a	2,019	n/a	n/a
1971	76,202	46,105	30,097	3,148	n/a	n/a	839	n/a	n/a	2,309	n/a	n/a
1972	84,203	52,129	32,074	3,310	2,121	1,189	919	533	286	2,391	1,488	903
1973	89,715	56,587	33,128	3,542	2,245	1,297	1,055	673	382	2,487	1,572	915
1974	94,154	61,150	33,004	3,750	2,358	1,392	1,061	653	408	2,689	1,705	984
1975	88,877	57,971	30,906	3,938	2,552	1,386	1,144	771	373	2,794	1,781	1,013
1976	83,521	55,249	28,272	4,190	2,673	1,517	1,293	805	488	2,897	1,868	1,029
1977	77,627	51,390	26,237	4,247	2,685	1,562	1,353	858	495	2,894	1,827	1,067
1978	72,348	47,375	24,973	4,207	2,632	1,575	1,464	880	584	2,743	1,752	991
1979	67,555	43,518	24,037	4,245	2,698	1,547	1,509	923	586	2,736	1,775	961
1980	65,283	41,521	23,762	4,193	2,517	1,676	1,581	896	685	2,612	1,621	991
1981	61,435	38,569	22,866	4,469	2,724	1,745	1,740	961	779	2,729	1,763	966

[a]In this table, clinical behavioral fields include clinical and school psychology, counseling, and guidance; nonclinical behavioral fields include anthropology, sociology, nonclinical psychology, and speech and hearing sciences.

[b]Numbers are lower than those presented in previous reports because speech pathology/audiology has been removed from the behavioral science taxonomy. It has been determined that this field is not equivalent to the behavioral field, speech and hearing sciences. Figures for 1961-81 were obtained from the U.S. Department of Education (1948-83; special tabulations from the Higher Education General Information Survey, 3/82, 4/82, and 3/83). Public and private figures for 1981 were estimated by the Committee.

[c]From the National Research Council (1958-82). Foreign nationals who received doctorates from U.S. institutions are included.

BLE C5 Total Undergraduate Degree-Credit Enrollment, Total B.A. Degrees, and Ratio of Behavioral Science B.A.s to Total B.A.s, by Control of , 1960-82

Total Undergraduate Degree-Credit Enrollment (thousands)						Total B.A. Degrees Awarded[c] (excluding first professional)			Ratio of Behavioral Sci. B.A.s to Total B.A.s[d]
Including First Professional[a]			Excluding First Professional[b]						
Total	Public	Private	Total	Public	Private	Total	Public	Private	Total
3,402	n/a	n/a	3,334	n/a	n/a	n/a	n/a	n/a	n/a
3,610	n/a	n/a	3,538	n/a	n/a	365,337	n/a	n/a	0.0452
3,891	n/a	n/a	3,813	n/a	n/a	382,822	n/a	n/a	0.0481
4,207	n/a	n/a	4,123	n/a	n/a	410,421	n/a	n/a	0.0508
4,529	n/a	n/a	4,438	n/a	n/a	460,467	n/a	n/a	0.0551
4,342	2,802	1,541	4,255	n/a	n/a	492,984	n/a	n/a	0.0585
4,829	3,184	1,645	4,732	n/a	n/a	524,117	n/a	n/a	0.0644
5,160	3,451	1,709	5,057	3,408	1,649	562,369	n/a	n/a	0.0695
5,557	3,810	1,747	5,437	3,758	1,679	636,863	n/a	n/a	0.0758
6,043	4,308	1,735	5,905	4,248	1,657	734,002	466,133	267,869	0.0804
6,529	4,749	1,780	6,377	4,685	1,692	798,070	523,442	274,628	0.0857
6,889	5,076	1,813	6,719	5,004	1,715	846,110	562,345	283,765	0.0901
7,104	5,302	1,802	6,913	5,221	1,692	894,110	604,471	289,639	0.0942
7,199	5,401	1,799	6,998	5,316	1,682	930,272	636,378	293,894	0.0964
7,396	5,589	1,807	7,187	5,501	1,686	954,376	657,455	296,921	0.0987
7,833	5,986	1,847	7,610	5,892	1,718	931,663	640,524	291,139	0.0954
8,468	6,520	1,948	8,234	6,423	1,811	934,443	640,799	293,644	0.0894
8,559	6,595	1,964	8,312	6,495	1,817	928,228	635,909	292,319	0.0836
8,722	6,696	2,026	8,471	6,593	1,878	930,201	633,183	297,018	0.0778
8,709	6,662	2,047	8,452	6,557	1,895	931,340	627,084	304,256	0.0725
8,962	6,850	2,112	8,699	6,744	1,955	940,251	629,338	310,913	0.0694
9,354	7,162	2,192	9,074	7,046	2,028	935,140	626,452	308,688	0.0657
n/a	n/a	n/a	n/a	n/a	n/a	945,000	632,772	312,228	0.0657

r 1960-64 were obtained from the U.S. Department of Education (1961-82), those for 1965-75 from the U.S. Department of 973-82), and the one for 1976 from the U.S. Department of Education (1974-82). Figures for 1977-81 were obtained by sub- ollment for master's and doctor's degrees from total degree-credit enrollment (U.S. Department of Education, 1974-82).

r 1960-66 were estimated at 98% of total undergraduate degree-credit enrollment (including first professional). 67-81 were obtained by subtracting first professional enrollment from total undergraduate enrollment (including first). First professional enrollment data for 1967-77 were obtained from the U.S. Department of Education (1959-79), data from the U.S. Department of Education (1961-82).

r 1961-81 were obtained from the U.S. Department of Education (1948-83). The total figure for 1982 is an intermediate pro- ined from the U.S. Department of Education (1973-82); the public and private figures for 1982 were estimated by the Committee.

ix Table C4 for number of baccalaureate degrees awarded in the behavioral sciences. For 1982, a constant ratio was assumed.

BLE C6 Graduate Enrollment in Psychology, Ph.D. Degrees Awarded in Psychology, and Ratio of Clinical Psychology
otal Psychology Ph.D.s, by Control of Institution, 1960-1982[a]

Graduate Enrollment in Psychology[b]			Ph.D. Degrees Awarded in Psychology[c]			Ratio of Clinical Psychology Ph.D.s to Total Psychology Ph.D.s[d]
Total	Public	Private	Total	Public	Private	Total
8,957	n/a	n/a	772	n/a	n/a	0.4067
10,677	n/a	n/a	820	n/a	n/a	0.4646
10,751	n/a	n/a	856	n/a	n/a	0.4229
11,344	n/a	n/a	890	n/a	n/a	0.4124
12,627	n/a	n/a	1,013	n/a	n/a	0.4630
13,733	n/a	n/a	954	n/a	n/a	0.4172
15,551	n/a	n/a	1,139	n/a	n/a	0.3854
15,685	n/a	n/a	1,295	n/a	n/a	0.4085
19,064	n/a	n/a	1,464	n/a	n/a	0.4187
21,643	n/a	n/a	1,756	n/a	n/a	0.3793
22,726	n/a	n/a	1,888	n/a	n/a	0.3745
25,342	n/a	n/a	n/a	n/a	n/a	0.3939
26,712	17,796	8,916	2,280	1,490	790	0.4031
29,157	19,669	9,488	2,458	1,541	917	0.4292
30,899	20,216	10,683	2,598	1,626	972	0.4084
32,794	20,910	11,884	2,751	1,783	968	0.4158
35,318	22,069	13,249	2,883	1,807	1,076	0.4485
35,363	21,393	13,970	2,990	1,864	1,126	0.4525
38,575	24,019	14,556	3,055	1,853	1,202	0.4792
39,152	23,975	15,177	3,091	1,918	1,173	0.4882
39,729	23,931	15,798	3,098	1,787	1,311	0.5103
40,574	23,719	16,855	3,357	1,963	1,394	0.5183
40,756	23,930	16,826	n/a	n/a	n/a	0.5263

for graduate enrollment and Ph.D. degrees awarded include all fields of psychology.

for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-82 were obtained from
al Science Foundation (1973-83a) except for the 1979 figure, which was interpolated. NSF numbers for 1978-82 may be
igher than numbers that would have been obtained from the Department of Education had data been collected for those
r the year 1977, NSF reported 37,390 graduate students enrolled in psychology; in comparison, the Department of
reported a somewhat lower figure of 35,363 (as shown in this table).

National Research Council (1958-82). Foreign nationals who received doctorates from U.S. institutions are

APPENDIX TABLE C7 Ph.D.s Employed in All Behavioral Science Fields, 1962-81a/

Fiscal Year	Total Labor Force	Academia (excluding postdocs.)b/ Total	Public	Private	Postdoc. Appts.	Business	Gov't.c/	Hospitals/ Clinics	Non-Profit	Self-Employed	Other	Unemployed and Seeking
1962	11,240	5,339	n/a	n/a	137	n/a	n/a	n/a	n/a	n/a	5,730	34
1963	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1964	13,606	8,143	n/a	n/a	209	n/a	n/a	n/a	n/a	n/a	5,227	27
1965	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1966	15,746	9,783	n/a	n/a	251	n/a	n/a	n/a	n/a	n/a	5,681	31
1967	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1968	19,953	12,915	n/a	n/a	331	n/a	n/a	n/a	n/a	n/a	6,667	40
1969	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1970	24,253	16,175	n/a	n/a	415	n/a	n/a	n/a	n/a	n/a	7,566	97
1971	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1972	28,983	18,602	n/a	n/a	513	910	2,112	2,783	904	1,560	1,372	227
1973	31,749	19,787	13,683	6,104	604	1,009	2,184	3,282	1,080	1,882	1,533	388
1974	35,267	22,324	n/a	n/a	603	1,346	2,255	4,198	958	2,193	1,140	250
1975	38,781	23,631	16,093	7,538	739	1,410	2,641	4,958	1,164	2,708	1,141	389
1976	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1977	44,351	25,588	17,728	7,860	1,038	1,789	2,950	5,640	1,496	3,648	1,436	766
1978	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1979	49,355	26,894	18,265	8,629	1,144	1,955	3,275	6,126	2,156	5,216	1,839	750
1980	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1981	53,917	28,277	19,059	9,218	1,016	2,735	3,391	6,560	2,112	7,279	1,829	718

a/Behavioral sciences include anthropology, sociology, psychology, and speech and hearing sciences. Figures for 1962-70 were estimated by the Committee. Figures for 1972-81 were obtained from the National Research Council (1973-82). Foreign nationals who received doctorates from U.S. institutions are included.

b/Public and private figures were adjusted by the Committee to include a small number of academically employed individuals for whom control of institution could not be determined.

c/Includes FFRDC laboratories for 1973 and 1975-81. For other years, FFRDC laboratories may be included in any category.

E C8 Ph.D.s Employed in the Clinical Behavioral Sciences, 1962-81[a]

otal abor orce	Academia (excluding postdocs.)[b] Total	Public	Private	Postdoc. Appts.	Business	Gov't.[c]	Hospitals/ Clinics	Non-Profit	Self-Employed	Other	Unemployed and Seeking
,231	1,351	n/a	n/a	35	n/a	n/a	n/a	n/a	n/a	2,836	9
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
,286	2,142	n/a	n/a	55	n/a	n/a	n/a	n/a	n/a	3,082	7
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
,995	2,576	n/a	n/a	66	n/a	n/a	n/a	n/a	n/a	3,345	8
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
,843	3,125	n/a	n/a	80	n/a	n/a	n/a	n/a	n/a	3,634	10
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
,162	4,076	n/a	n/a	105	n/a	n/a	n/a	n/a	n/a	3,957	24
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
,511	4,159	n/a	n/a	124	46	1,135	2,489	293	1,251	967	47
,587	4,325	3,245	1,080	168	41	1,119	2,899	385	1,509	1,042	99
,316	4,873	n/a	n/a	216	202	1,114	3,795	265	1,883	932	36
,873	5,151	3,738	1,413	181	169	1,261	4,431	381	2,246	994	59
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
7,591	5,437	4,116	1,321	384	413	1,252	5,102	676	3,147	1,097	83
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1,205	5,786	3,969	1,817	317	452	1,664	5,644	1,119	4,758	1,337	128
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3,749	6,147	4,345	1,802	295	839	1,671	5,972	1,045	6,196	1,399	185

ehavioral sciences include clinical and school psychology, counseling, and guidance. Figures for 1962-70 were estimated by the Committee. 1972-81 were obtained from the National Research Council (1973-82). Foreign nationals who received doctorates from U.S. institutions are

private figures were adjusted by the Committee to include a small number of academically employed individuals for whom control of could not be determined.

FFRDC laboratories for 1973 and 1975-81. For other years, FFRDC laboratories may be included in any category.

BLE C9 Ph.D.s Employed in the Nonclinical Behavioral Sciences, 1962-81[a]

Total Labor Force	Academia (excluding postdocs.)[b] Total	Public	Private	Postdoc. Appts.	Business	Gov't.[c]	Hospitals/ Clinics	Non-Profit	Self-Employed	Other	Unemployed and Seeking
7,009	3,988	n/a	n/a	102	n/a	n/a	n/a	n/a	n/a	2,894	25
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3,320	6,001	n/a	n/a	154	n/a	n/a	n/a	n/a	n/a	2,145	20
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9,751	7,207	n/a	n/a	185	n/a	n/a	n/a	n/a	n/a	2,336	23
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3,104	9,790	n/a	n/a	251	n/a	n/a	n/a	n/a	n/a	3,033	30
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6,091	12,099	n/a	n/a	310	n/a	n/a	n/a	n/a	n/a	3,609	73
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3,472	14,443	n/a	n/a	389	864	977	294	611	309	405	180
0,162	15,462	10,438	5,024	436	968	1,065	383	695	373	491	289
1,951	17,451	n/a	n/a	387	1,144	1,141	403	693	310	208	214
9,908	18,480	12,355	6,125	558	1,241	1,380	527	783	462	147	330
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6,760	20,151	13,612	6,539	654	1,376	1,698	538	820	501	339	683
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3,150	21,108	14,296	6,812	827	1,503	1,611	482	1,037	458	502	622
n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
0,168	22,130	14,714	7,416	721	1,896	1,720	588	1,067	1,083	430	533

al behavioral sciences include anthropology, sociology, nonclinical psychology, speech and hearing sciences. Figures for 1962-70 were the Committee. Figures for 1972-81 were obtained from the National Research Council (1973-82). Foreign nationals who received doctorates nstitutions are included.

private figures were adjusted by the Committee to include a small number of academically employed individuals for whom control of could not be determined.

FFRDC laboratories for 1973 and 1975-81. For other years, FFRDC laboratories may be included in any category.

APPENDIX TABLE C10 Behavioral Sciences Faculty/Student Ratio, 1962-80[a]

Fiscal Year	Faculty (F)	4-Yr. Weighted Avg. Enrollment (WS)	Ph.D. Faculty/ Student Ratio (F/WS)
1962	5,339	192,212[b]	0.0278[b]
1963	n/a	211,871	n/a
1964	8,143	244,244	0.0333
1965	n/a	277,685	n/a
1966	9,783	313,743	0.0312
1967	n/a	355,876	n/a
1968	12,915	407,028	0.0317
1969	n/a	469,068	n/a
1970	16,175	537,604	0.0301
1971	n/a	590,566	n/a
1972	18,602	662,806	0.0281
1973	19,787	697,851	0.0284
1974	22,324	708,379	0.0315
1975	23,631	702,139	0.0337
1976	n/a	692,368	n/a
1977	25,588	683,093	0.0375
1978	n/a	670,264	n/a
1979	26,894	649,812	0.0414
1980	27,586[b]	631,845	0.0437[b]

[a] Faculty is defined as all Ph.D.s academically employed in the behavioral sciences (excluding postdoctoral appointments). Students are defined as a 4-year weighted average of enrollments, i.e., $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = total graduate and undergraduate enrollments in the behavioral sciences. See Appendix Table C1 for supporting data.

[b] Estimated by the Committee.

APPENDIX TABLE C11 Behavioral Science R and D Expenditures in Colleges and Universities, by Control of Institution, 1960-81 ($ millions)

Fiscal Year	Current Dollars[a]			1972 Dollars			Implicit GNP Price Deflator[b] (1972 = 100.0)
	Total	Public	Private	Total	Public	Private	
1960	23.6	n/a	n/a	34.3	n/a	n/a	68.70
1961	27.9	n/a	n/a	40.2	n/a	n/a	69.30
1962	33.0	n/a	n/a	46.8	n/a	n/a	70.50
1963	39.5	n/a	n/a	55.1	n/a	n/a	71.60
1964	46.6	n/a	n/a	64.1	n/a	n/a	72.70
1965	52.4	n/a	n/a	70.5	n/a	n/a	74.30
1966	60.1	n/a	n/a	78.3	n/a	n/a	76.80
1967	77.4	n/a	n/a	98.0	n/a	n/a	79.00
1968	97.9	n/a	n/a	118.5	n/a	n/a	82.60
1969	98.2	n/a	n/a	113.3	n/a	n/a	86.70
1970	103.6	n/a	n/a	113.4	n/a	n/a	91.40
1971	115.9	n/a	n/a	120.7	n/a	n/a	96.00
1972	127.6	84.3	43.4	127.6	84.3	43.4	100.00
1973	135.3	92.6	42.7	127.8	87.5	40.3	105.80
1974	137.7	95.0	42.7	118.7	81.9	36.8	116.00
1975	149.1	103.4	45.7	117.2	81.3	35.9	127.20
1976	144.1	99.6	44.5	107.6	74.4	33.3	133.90
1977	147.1	99.2	47.8	103.8	70.0	33.7	141.70
1978	156.6	107.3	49.3	103.0	70.6	32.4	152.05
1979	174.9	120.5	54.4	105.7	72.8	32.9	165.46
1980	199.8	137.6	62.2	112.6	77.6	35.0	177.36
1981	222.5	154.4	68.1	114.9	79.8	35.2	193.58

[a] Figures for even years from 1964-70 and for all years from 1972-81 were obtained from the National Science Foundation (1975-83). The 1978 figures are NSF estimates. Those for other years were estimated by the Committee. Items may not sum to totals due to rounding.

[b] From the U.S. Bureau of the Census.

.PPENDIX TABLE C12 Average Behavioral Science R and D Expenditures per School .n Colleges and Universities, by Control of Institution, 1972-81[a]
1972 $, thousands)

'iscal [ear	Average R and D Expenditures			Number of Schools Reporting[b]		
	Total	Public	Private	Total	Public	Private
L972	216	251	169	591	335	256
L973	216	261	158	591	335	256
L974	199	244	142	596	336	260
L975	219	252	169	536	323	213
1976	201	231	156	535	322	213
1977	194	217	158	536	322	214
1978	183	213	140	562	331	231
1979	187	219	141	565	332	233
1980	200	234	152	563	332	231
1981	204	240	152	563	332	231

a/See Appendix Table C11 for supporting data.

b/From the National Science Foundation. For 1978 the number of doctorate-granting institutions was obtained from NSF; the number of master's-granting institutions was estimated by the Committee.

X TABLE C13 Ph.D.s Academically Employed in the Behavioral Sciences, by Employment Status and Type of Institution, 1973-81[a]/

	Employment Status	All Behavioral Fields: Type of Institution: Total	4-Year	2-Year	Clinical Behavioral: Type of Institution: Total	4-Year	2-Year	Nonclinical Behavioral: Type of Institution: Total	4-Year	2-Year
	Total	19,787	19,200	587	4,325	4,142	183	15,462	15,058	404
	Full-Time	19,079	18,571	508	4,142	3,970	172	14,937	14,601	336
	Part-Time	708	629	79	183	172	11	525	457	68
	Total	23,631	22,929	702	5,151	4,956	195	18,480	17,973	507
	Full-Time	22,894	22,261	633	4,975	4,787	188	17,919	17,474	445
	Part-Time	737	668	69	176	169	7	561	499	62
	Total	25,588	24,711	877	5,437	5,271	166	20,151	19,440	711
	Full-Time	24,741	23,974	767	5,232	5,073	159	19,509	18,901	608
	Part-Time	847	737	110	205	198	7	642	539	103
	Total	26,894	26,006	888	5,786	5,617	169	21,108	20,389	719
	Full-Time	25,564	24,839	725	5,459	5,314	145	20,105	19,525	580
	Part-Time	1,330	1,167	163	327	303	24	1,003	864	139
	Total	28,277	27,104	1,173	6,147	5,802	345	22,130	21,302	828
	Full-Time	27,137	26,105	1,032	5,778	5,461	317	21,359	20,644	715
	Part-Time	1,140	999	141	369	341	28	771	658	113
Annual	Total	4.6	4.4	9.0	4.5	4.3	8.2	4.6	4.4	9.4
ate	Full-Time	4.5	4.3	9.3	4.2	4.1	7.9	4.6	4.4	9.9
3-81	Part-Time	6.1	6.0	7.5	9.2	8.9	12.4	4.9	4.7	6.6

ne National Research Council (1973-82). Foreign nationals who received doctorates from U.S. institutions are included.
als on postdoctoral appointments are excluded.

APPENDIX TABLE C14 Annual Number of Behavioral Scientists in the FY 1981 Ph.D. Labor Force Expected to Reach the Age of 65 During the FY 1983-2001 Period[a]

Fiscal Year	Employment Sector: Total	Academia	Other Sectors
1983	425	259	166
1985	452	273	179
1987	772	481	291
1989	731	427	304
1991	1,063	585	478
1993	1,144	670	474
1995	1,104	684	420
1997	1,022	512	510
1999	1,089	642	447
2001	1,156	700	456

[a] From the National Research Council (1973-82).

APPENDIX D
Miscellaneous Data

APPENDIX TABLE D1 Estimates of the Total Population of the United States, by Age Group, 1971-2051[a]

Fiscal Year	Age Group 15-19 Years	20-24 Years	25-29 Years
1971	19,333	17,202	13,736
1972	19,789	18,159	14,041
1973	20,296	18,153	15,240
1974	20,719	18,521	15,786
1975	21,042	18,975	16,521
1976	21,285	19,527	17,280
1977	21,534	19,986	18,274
1978	21,540	20,499	18,277
1979	21,496	20,946	18,683
1980	21,402	21,297	19,178
1981	21,123	21,605	19,763
1982	20,433	21,938	20,173
(Projected - Middle Series)			
1983	19,829	21,920	20,768
1984	19,166	21,852	21,168
1985	18,646	21,687	21,523
1986	18,405	21,282	21,830
1991	16,957	18,567	21,503
1996	16,951	17,129	18,807
2001	18,950	17,126	17,380
2026	18,468	18,121	18,549
2051	18,236	18,363	18,873

[a]From the U.S. Bureau of the Census (1965-82). Includes armed forces overseas.

APPENDIX TABLE D2 NIH/ADAMHA/HRSA Expenditures for Research Training Programs, 1971-81 ($ millions)

Fiscal Year	Total NIH/ADAMHA/HRSA: Total Amount, Constant 1972 $ d/	Total Amount, Current $	Fellowships #	Fellowships Amt.	Training Grants #	Training Grants Amt.	NIH a/: Total Amount, Current $	Fellowships #	Fellowships Amt.	Training Grants #	Training Grants Amt.
1971	178.6	171.5	-	-	-	-	152.9	2,718	23.8	2,111	129.1
1972	178.1	178.1	-	-	-	-	157.6	2,264	21.5	2,024	136.1
1973	120.2	127.2	-	-	-	-	115.3	1,233	12.2	1,696	103.1
1974	179.2	207.9	-	-	-	-	186.5	2,267	30.6	2,922	155.9
1975	139.2	177.1	2,657	34.1	1,979	143.0	156.8	2,056	27.8	1,739	129.0
1976	105.7	141.6	2,107	27.9	1,570	113.7	122.0	1,652	23.2	1,339	98.8
1977	105.4	149.4	2,389	31.2	1,426	118.2	130.4	1,975	27.3	1,200	103.1
1978	108.6	165.1	2,423	32.8	1,551	132.2	147.2	2,070	29.7	1,321	117.4
1979	100.4	166.2	2,539	34.9	1,466	131.2	148.0	2,208	31.8	1,256	116.1
1980	113.9	202.1	2,258	42.4	1,718	159.7	181.1	1,973	38.9	1,505	142.2
1981	104.5	202.2	2,072	39.4	1,560	162.8	180.4	1,752	35.5	1,359	144.9

Fiscal Year	ADAMHA b/: Total Amount, Current $	Fellowships #	Fellowships Amt.	Training Grants #	Training Grants Amt.	HRSA, Division of Nursing c/: Total Amount, Current $	Fellowships #	Fellowships Amt.	Training Grants #	Training Grants Amt.
1971	16.7	n/a	n/a	n/a	n/a	1.9	183	0.9	9	1.0
1972	19.2	n/a	n/a	n/a	n/a	1.3	146	0.6	9	0.7
1973	10.3	n/a	n/a	n/a	n/a	1.6	136	0.6	10	1.0
1974	20.1	n/a	n/a	n/a	n/a	1.3	115	0.6	9	0.7
1975	19.7	570	6.1	232	13.6	0.6	31	0.2	8	0.4
1976	19.4	414	4.6	230	14.8	0.16	41	0.08	1	0.08
1977	18.2	318	3.3	223	14.9	0.8	96	0.6	3	0.2
1978	16.9	231	2.3	227	14.6	1.0	122	0.8	3	0.2
1979	17.2	219	2.3	207	14.9	1.0	112	0.8	3	0.2
1980	20.0	190	2.8	210	17.2	0.99	95	0.7	3	0.3
1981	20.8	205	3.0	200	17.8	0.99	115	0.9	1	0.1

a/From NIH (1966-82, 1982 edition, p. 22).

b/Figures for 1971-74 were obtained from ADAMHA (1978-81, 1980 edition, p. 33); figures for 1975-81 were from special tabulations prepared annually by ADAMHA, Office of the Administrator.

c/From HRSA, Division of Nursing. Figures for 1971-76 represent Special Nurse Research Fellowship and Nurse Scientist Training Grant Programs. Figures for 1977-81 were obtained from HRSA, Division of Nursing (special tabulation, 4/81). Authority for NRSA research training programs in the Division of Nursing began in FY 1977.

d/Obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--see Appendix Table B7).

E D3 NIH Research Grant Applicants, by Type of Degree, 1970-82[a]/

Degree Types			M.D.			Ph.D.			M.D./Ph.D.			Other Degree		
l i- s	Number Approved	Number Awarded	Total Appli- cants	Number Approved	Number Awarded	Total Appli- cants	Number Approved	Number Awarded	Total Appli- cants	Number Approved	Number Awarded	Total Appli- cants	Number Approved	Number Awarded
8	4,666	2,752	2,150	1,424	988	3,861	2,750	1,438	593	408	285	194	84	41
8	4,731	2,985	2,094	1,453	1,035	3,764	2,742	1,586	642	451	312	208	85	52
4	5,502	3,917	2,392	1,700	1,284	4,304	3,177	2,173	711	516	381	217	109	79
7	5,119	2,906	2,312	1,618	1,025	4,106	2,901	1,535	705	505	296	194	95	50
4	6,688	4,693	2,616	1,978	1,465	4,992	3,975	2,692	782	623	451	244	112	85
4	7,140	5,064	2,751	2,044	1,466	5,530	4,313	3,021	823	648	488	270	135	89
3	6,982	4,300	2,796	1,938	1,276	5,807	4,313	2,546	848	612	413	252	119	65
1	7,934	4,197	3,122	2,237	1,276	6,460	4,886	2,449	927	681	405	252	130	67
2	9,291	5,532	3,260	2,506	1,511	7,326	5,863	3,437	1,016	792	510	250	130	74
1	9,701	6,197	3,238	2,494	1,648	7,830	6,276	3,950	982	790	519	271	141	80
1	9,488	5,225	3,292	2,534	1,465	7,480	6,011	3,221	973	800	480	246	143	59
1	10,312	5,306	3,166	2,557	1,350	7,970	6,574	3,325	1,084	913	504	401	268	127
7	13,017	5,224	3,650	3,047	1,281	10,087	8,705	3,422	1,207	1,036	434	353	229	87

tional Research Council (1979-83, Query #5). Includes only competing applicants who have been reviewed.

D4 NRSA Training Expenditures as a Percentage of NIH/ADAMHA/HRSA Research Obligations, 1971-81 ($ millions)

otal NIH/ADAMHA/HRSA			NIH[a/]			ADAMHA[b/]			HRSA, Division of Nursing[c/]		
esearch $	Training $	% of Research $	Research $	Training $	% of Research $	Research $	Training $	% of Research $	Research $	Training $	% of Research $
960.7	171.5	17.9	842.7	152.9	18.1	116.0	16.7	14.4	2.0	1.9	95.0
1,173.8	178.1	15.2	1,041.1	157.6	15.1	130.3	19.2	14.7	2.4	1.3	54.2
1,205.5	127.2	10.6	1,081.4	115.3	10.7	121.6	10.3	8.5	2.5	1.6	64.0
1,601.3	207.9	13.0	1,443.4	186.5	12.9	155.3	20.1	12.9	2.6	1.3	50.0
1,674.7	177.1	10.6	1,532.2	156.8	10.2	139.1	19.7	14.2	3.4	0.6	17.6
1,843.6	141.6	7.7	1,667.7	122.0	7.3	173.1	19.4	11.2	2.8	0.16	5.7
1,999.6	148.6	7.4	1,836.9	130.4	7.1	157.7	18.2	11.5	5.0	0.8	16.0
2,227.3	164.1	7.4	2,061.0	147.2	7.1	161.3	16.9	10.5	5.0	1.0	20.0
2,594.6	165.2	6.4	2,393.7	148.0	6.2	196.0	17.2	8.8	4.9	1.0	20.4
2,772.3	201.1	7.3	2,555.6	181.1	7.1	211.7	20.0	9.4	5.0	1.0	20.0
2,874.0	201.2	7.0	2,662.4	180.4	6.8	206.6	20.8	10.1	5.0	1.0	20.0

)66-82, 1982 edition, p. 22).

(1978-81, 1980 edition, p. 17).

rom annual reports provided by HRSA, Division of Nursing.

APPENDIX TABLE D5 Classifications of Fields

NIH[a]

BIOMEDICAL SCIENCES

General Medical and Biological Sciences

- • Anatomy
- • Biochemistry
- • Biophysics
- • Microbiology
- • Pathology
- • Pharmacology
- • Physiology
- Multidisciplinary[b]
- Radiation, Nonclinical
- Entomology
- • Genetics
- • Nutrition
- Hydrobiology
- Ecology
- • Cell Biology
- • Zoology
- Botany
- • Biology NEC
- • General Med. and Bio. Sci.
- • Environmental Sciences
- • Toxicology

Mathematics, Physical Sciences, Engineering, Other

- Mathematics
- Chemistry
- Physics
- Earth and Related Sciences
- Agricultural Fields
- Engineering
- Engineering, Health-Related

Other Health-Related Fields

- • Biostatistics
- • Epidemiology

Community and Environmental Health

- Accident Prevention
- Disease Prevention and Control
- Maternal and Child Health
- Dental Public Health
- Mental Health
- Hospital and Medical Care
- Other Community Health
- Radiological Health
- Water Pollution Control
- Air Pollution
- Environmental Engineering
- Food Protection
- Occupational Health
- Health Administration
- Social Work
- Pharmacy
- Other Health-Related Professions
- Other Environmental Health Fields

ADAMHA[c]

BIOMEDICAL SCIENCES

• Anatomy

- Anatomy
- Histology
- Pathology
- Experimental Pathology
- Cell Biology
- Embryology

• Biology

- Radiobiology
- Entomology
- Nutrition
- Molecular Biology
- Zoology
- Botany
- Biology
- Developmental Biology
- Neurobiology
- Teratology
- Aging Process
- Oral Biology

• Genetics

- Genetics
- Mutagenesis

• Microbiology/Immunology

- Microbiology
- Bacteriology
- Immunology
- Mycology
- Parasitology
- Virology

• Pharmacology

- Pharmacology

• Physiology

- Physiology
- Reproductive Physiology
- Endocrinology
- Communicative Sciences
- Physiological Optics

• Toxicology

- Toxicology
- Aquatic
- Environmental
- Forensic
- Inhalation
- Occupational/Safety

Mathematics, Physical Sciences, Engineering, Other

Chemistry

- Biochemistry
- Biomaterials
- Chemistry
- Polymer Chemistry
- Medicinal Chemistry
- Organic Chemistry
- Physical Chemistry
- Inorganic Chemistry

Physics/Engineering

- Biophysics
- Radiation Physics
- Biomedical Engineering
- Environmental Engineering
- Physics
- Engineering

Other Health-Related Fields

Statistics/Epidemiology/Computer Science

- • Biostatistics
- • Epidemiology
- Information Sciences
- Mathematics
- Statistics
- Computer Sciences

NAS[d]

• BASIC BIOMEDICAL SCIENCES

- Anatomy
- Embryology
- Animal Physiology
- Biochemistry
- Molecular Biology
- Biostatistics/Biomathematics
- Biomedical Engineering
- Biophysics
- Environmental Sciences, General
- Environmental Sciences, Other
- Environmental Health
- General Biology
- Genetics
- Immunology
- Parasitology
- Microbiology
- Pathology
- Pharmaceutical Chemistry
- Pharmacology
- Pharmacy
- Public Health and Epidemiology
- Hospital Administration
- Veterinary Medicine
- Zoology
- Cytology
- Nutrition/Dietetics
- Food Science and Technology
- Other Biological Sciences
- General Medical Sciences
- Medicine and Surgery
- Dentistry
- Optometry, Ophthalmology
- Other Medical Sciences

APPENDIX TABLE D5 Classifications of Fields (Continued)

NIH[a]

BEHAVIORAL SCIENCES

Psychology

- General and Experimental
- Comparative and Animal
- Physiological
- Developmental
- Personality
- Social – Psychological Aspects
- Abnormal
- Clinical
- Educational, Counseling, and Guidance
- Other Psychology

Other Behavioral Sciences

- Sociology
- Social Psychology – Sociological Aspects
- Anthropology
- Social Sciences and Related Disciplines
- Other Fields

CLINICAL SCIENCES

- Internal Medicine
- Allergy
- Pediatrics
- Geriatrics
- Obstetrics-Gynecology
- Radiology
- Surgery
- Otorhinolaryngology
- Ophthalmology
- Anesthesiology
- Neuropsychiatry
- Neurology
- Psychiatry
- Preventive Medicine
- Other Clinical Medicine
- Veterinary Medicine
- Clinical Dentistry

NURSING RESEARCH

ADAMHA[c]

BEHAVIORAL SCIENCES

Psychology

- Experimental and General
- Psychophysics
- Physiological Psychology and Psychobiology
- Developmental and Child
- Personality
- Social
- Community and Ecological

Other Behavioral Sciences

- Health Administration and Public Health
- Education and Guidance
- Sociology
- Demography or Population Dynamics
- Anthropology
- Linguistics
- Social Sciences and Related Disciplines
- Economics
- Political Science
- Bioethics
- Social/Behavioral Sciences

CLINICAL SCIENCES

- Psychiatry
- Other Clinical Medicine
- Nursing
- Social Work
- Clinical Psychology

NAS[d]

BEHAVIORAL SCIENCES

Psychology

- General
- Clinical
- Counseling and Guidance
- Developmental and Gerontological
- Educational
- School
- Experimental
- Comparative
- Physiological
- Psychometrics
- Social
- Industrial and Personnel
- Personality
- Human Engineering
- Behavior/Ethology
- Other Psychology

Other Behavioral Sciences

- Anthropology
- Sociology
- Speech and Hearing Sciences

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*These fields correspond to those defined by the Committee as the Basic Biomedical Sciences. See NRC (1975-81, 1977 Report, p. 29).

[a]Since 1962, the NIH has used a classification scheme called the Discipline/Specialty/Field Code (DSF) to classify areas of training for its trainees and fellows. The major categories of that scheme are shown in this table. They have been grouped into 4 broad areas of research that the Committee has established for purposes of this study.

[b]Most of the trainees in the Medical Scientist Training Program are classifed in this category.

[c]These fields represent the lexicon established by ADAMHA to classify areas of training for its NRSA trainees and fellows.

[d]These fields are used by the National Research Council's Survey of Earned Doctorates and Survey of Doctorate Recipients to identify fields of Ph.D. specialization and fields of employment.

APPENDIX E
Biotechnology Survey Questionnaire

Cornell University

Ithaca, New York 14853

January 25, 1983

Hybrigen
P.O. Box 31083
Los Angeles, CA 90031

Dear Colleague:

The Congressional Office of Technology Assessment (OTA) and the National Academy of Science's (NAS) Committee on National Needs for Biomedical and Behavioral Research Personnel have a mutual interest in determining the nation's need for research personnel. I am chairman of the NAS Committee's Panel on Basic Biomedical Sciences. We are particularly concerned that there be an adequate number of people trained in areas of the new biotechnology.

I am writing to ask your assistance in collecting some information on this issue. You could help us greatly in our efforts to get a profile of current employment opportunities and a sense of future demand in biotechnology and related industries by responding to the three questions on the attached page. To be useful in our report to the Congress, we need your answers before February 28, 1983. The tabulated data from the questionnaire will be published. Only OTA and the NAS panel will have access to the individual responses.

If you have additional comments or suggestions that you think would assist us, please include them with your response. A self-addressed envelope is enclosed. Also, if you have any questions concerning the questionnaire, don't hesitate to call me at (607) 256-3374.

With thanks for your help.

Yours sincerely,

R Barker

Robert Barker, Ph.D.
Director, Division of Biological Sciences
Cornell University

RB:db
Enclosures

COMPANY NAME AND ADDRESS:

____

____

____

____

PERSON COMPLETING THIS FORM:
Name:
____

Phone Number:
____

For the purpose of this questionnaire, Biotechnology is defined as the application of novel biological strategies (rDNA, cell-fusion, mobilized cells or enzymes) for biochemical processi

1. What year did your company begin research or development in activities related to the new biotechnology? ____________

2. Please check all areas of biotechnology application in which your company is involved:

a) _____ fine chemicals
b) _____ bulk chemicals
c) _____ pharmaceuticals
d) _____ animal agriculture
e) _____ biomass conversion
f) _____ human diagnostics
g) _____ plant agriculture
h) _____ mineral leaching and mining
i) _____ pollution control
j) _____ enhanced oil recovery
k) _____ other; specify ______________

PLEASE INCLUDE ANY COMMENTS ON REVERSE

3.

SPECIALTIES	(1) Check if you are experiencing personnel shortages in any of these specialties.			(2) No. scientists currently on staff (list each employee only once).			(3) No. you intend to retain during next 18 months.			(4) Expected No. of scientists to be hired in next 18 months.			(5) For vacant positions do you expect to:		
	Ph.D.	MS	BS	Ph.D.	MS	BS	Ph.D.	MS	BS	Ph.D.	MS	BS	Hire from Industry	Hire from Academia	Retra curre Sta
a) Recombinant DNA/molecular genetics															
b) Hybridomas/monoclonal antibodies															
c) animal reproduction/embryotransplantation															
d) classical genetics															
e) gene synthesis															
f) enzymology/immobilized systems															
g) industrial microbiology															
h) bioprocess engineering															
j) analytical biochemistry															
k) biochemistry, general															
l) Cell culture															
m) Cell fusion															
n) Cell biology/physiology															
o) plant molecular biology															
p) plant biology/physiology															
q) pharmacology															
r) toxicology															
s) microbiology, general															
t) physiology															
u) Other biotechnology specialties (specify) ______________															

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