Appendixes

Appendix A

The Education and Utilization of Biomedical Research Personnel

Introduction

As a nation, we spend $300 billion per year on health care, or 10 percent of the gross national product (GNP). National attention to biomedical research and its potential for health benefit has been consistently strong since World War II, driven by the hope that science will provide us with longer and healthier lives.

These early beginnings lead to a relatively high level of Federal support for both research and training in the biomedical sciences in comparison to other disciplines. The Government, through the National Institutes of Health (NIH), made an early commitment to the training of biomedical research personnel through the establishment of the NIH training and fellowship programs. In addition, Congress has ensured a substantial and consistent level of support for biomedical research through favorable appropriations to NIH, the parent agency for federally funded biomedical research programs. As a result of this two-pronged Federal approach to the biomedical sciences through support of both research and training programs, the biomedical research field has suffered few of the critical personnel shortages and/or surpluses found in other scientific disciplines, It is, therefore, worth examining the Federal program for training and supporting biomedical research personnel in some depth. It is an example of a continuous and mostly successful Federal personnel policy in an important scientific field.

Basic Biomedical Research Personnel [Ph.D.s]

Training

The higher education training system in basic biomedical research consists of at least two, and often three, stages. Virtually all biomedical scientists obtain a doctorate, although exceptions do exist. In addition, the Institute of Medicine (IOM) estimates that 60 percent of Ph.D. recipients in the basic biomedical sciences go on to postdoctoral appointments. Postdoctoral appointments are considered by some to be a holding pool for the Ph.D. population in search of employment. Recently, it has been suggested that postdoctoral training is also an essential educational experience for the biomedical scientist, and essential to success as an independent investigator.[1] Rapidly developing areas of research, it is argued, require more intensive and extensive training.

IOM estimates that of the postdoctoral population with doctorates from U.S. universities 30 percent are women and 10 percent hold foreign citizenship.[2] Foreign scientists have comprised approximately one-third of the total population of biomedical postdoctoral appointees since **1975.**

The typical biomedical researcher spends 4 years in undergraduate work, 5 to 7 years in graduate school to receive the Ph. D., and 2 to 4 years in a postdoctoral appointment. Figure A-1 illustrates the doctoral training system in the biomedical sciences.

Figure A-2 shows the distribution of primary sources of support for graduate students enrolled in Ph. D.-granting biomedical science departments, in 1975 and 1981. In addition to Federal sources of support, biomedical science students rely on teaching assistantships and self-support. NIH is the major source of support for postdoctoral training in clinical research, supplying nearly *90* percent of all training funds.[3] The National Science Foundation (NSF) provides for approximately 45 predoctoral fellowships per year in the biomedical sciences.[4]

It is only in the past 12 years that Federal programs for biomedical research training have been centralized. In 1973, the Nixon Administration proposed phasing out all training grant and fellowship programs of NIH; the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA); and the Health Resources Administration (HRA). Congress responded, in *197'4,* by passing the National Research Service Award (NRSA) Act (Title I, Public Law 93-348) that consolidated previous research training authorities under the Public Health Service Act. The NRSA Act is the only existing authority under which NIH supports training for biomedical and behavioral research careers. Threats to the NRSA program have appeared in every admin-

[1] Institute of Medicine, *Personnel Needs and Training for Biomedical and Behavioral Research: 1983 Report* (Washington, DC: National Academy Press, 1983).

[2] Ibid., p. 61.

[3] Thomas E. Malone, "Assuring the Supply of Clinical Investigators" (typescript), National Institutes of Health, 1981.

[4] Personal communication with Terence Porter, Science and Engineering Education, National Science Foundation, March 1985.

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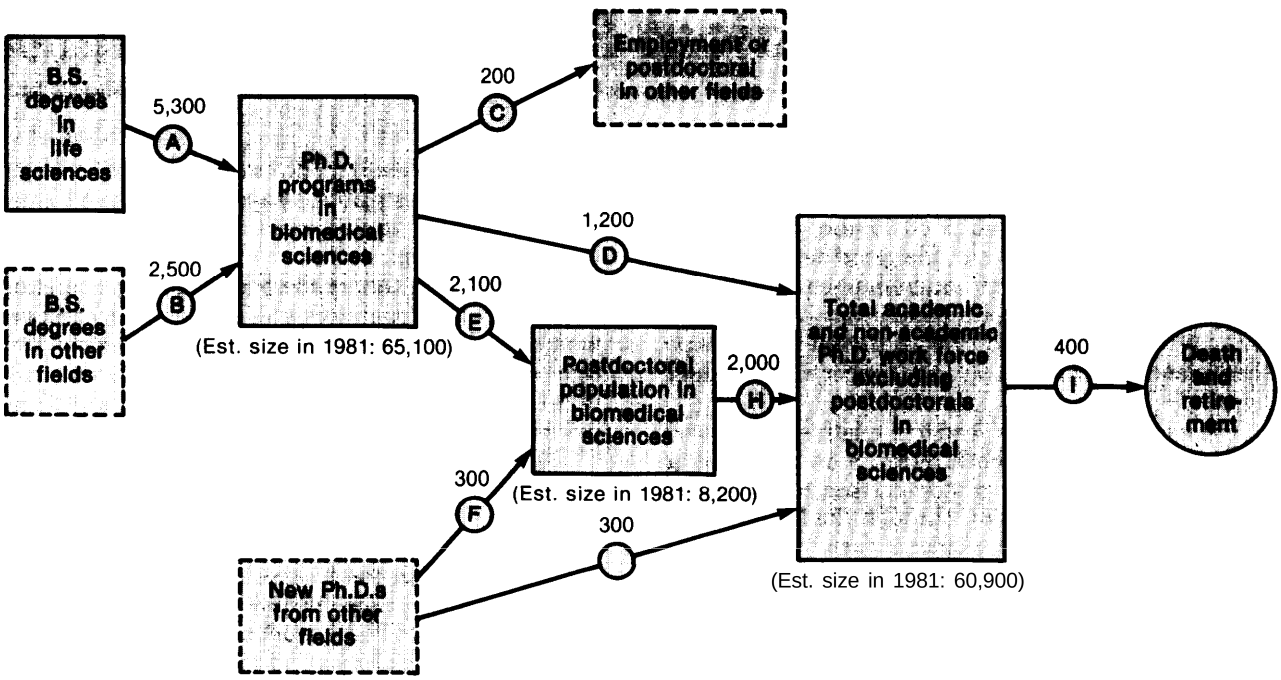
Figure A-1 .—Doctoral Training System in the Biomedical Sciences



NOTE: 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 reentry into the labor force

SOURCE IOM Report on *Personnel Needs, 1983.*

istration budget between **1978 and 1985** only to be relieved by Congress.

NIH devotes 10 percent of NRSA appropriations to special programs in minority access, the Medical Scientists program leading to a combination M. D./Ph.D. degree, and short-term training programs in medical schools. Predoctoral training accounts for 35 percent of the NIH NRSA program. The program's major emphasis, however, is on postdoctoral training, which receives 55 percent of NRSA funds in the belief that changing national needs can be most quickly met by a large and well-trained postdoctoral pool.

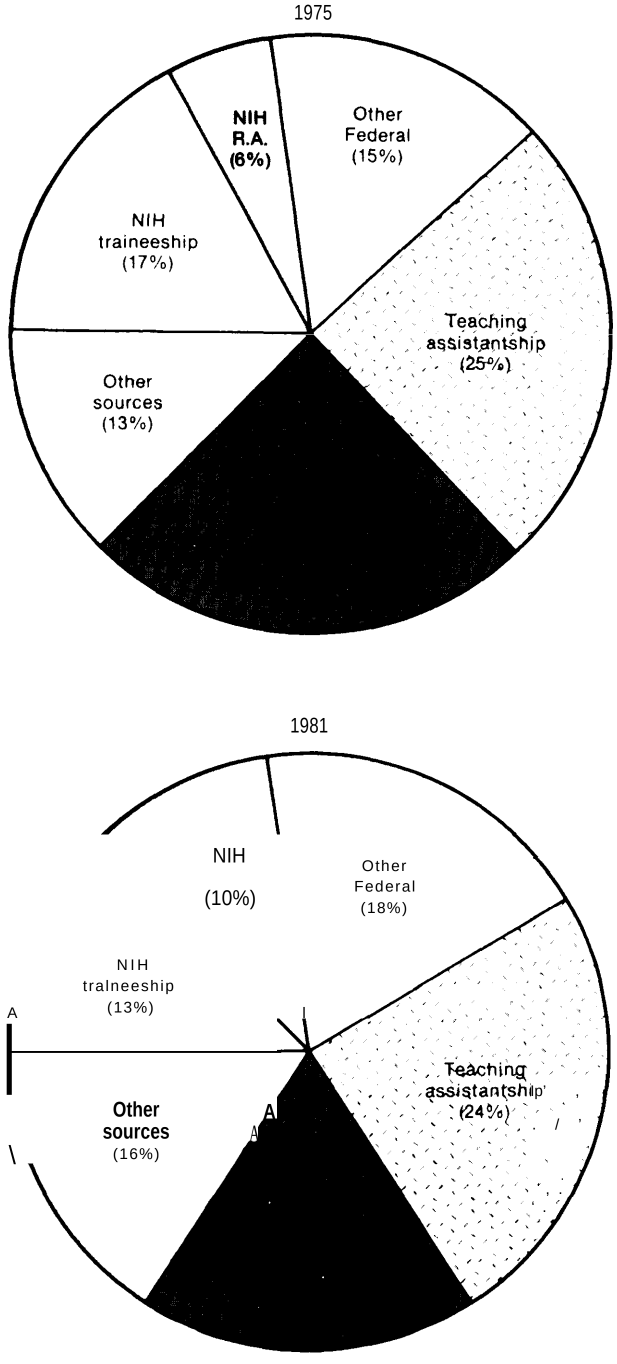
Funds are awarded for predoctoral and postdoctoral stipends through a system of individual fellowships and institutional training grants. Institutional training grants must survive peer review in national competition, and require a substantial commitment on the part of the institution to share **in the maintenance of a train**ing environment. They are limited to those institutions with the tradition and history of producing high-quality investigators and the financial resources to accept the necessary cost-sharing burden. Institutional training grants provide the program director with a number of full-time training positions. Individual fellowship awards, on the other hand, allow the applicants to develop a research training project under the supervision of a sponsor. The individual fellow tends to be further along in the training process than the institutional fellow (i.e., at the postdoctoral level). In 1985, the average annual stipend for the predoctoral fellowship is $6,552; the range for postdoctoral awards is $16,000 to 30,000 per year.

By 1971, NIH training grants and fellowships supported or assisted 37.3 percent of the Nation's full-time graduate students in the medical sciences and 1 percent in the life sciences.[5] Between 1961 and 1972, NIH programs furnished financial assistance through fellowships and institutional training grants to more than 30,000 graduate (predoctoral) students in the health-related disciplines. In addition, more than **27,000** biomedical scientists received postdoctoral support through NIH programs.[6] Since 1972, individual awards for predoctoral students have been eliminated and the numbers of predoctorals on training grants have been reduced. Between fiscal years 1969 and 1980, the number of predoctoral students receiving NIH support dropped by about 50 percent (see figure A-3). Nevertheless, between 1973 and 1983, more than one out

[5] Malone, op. cit.

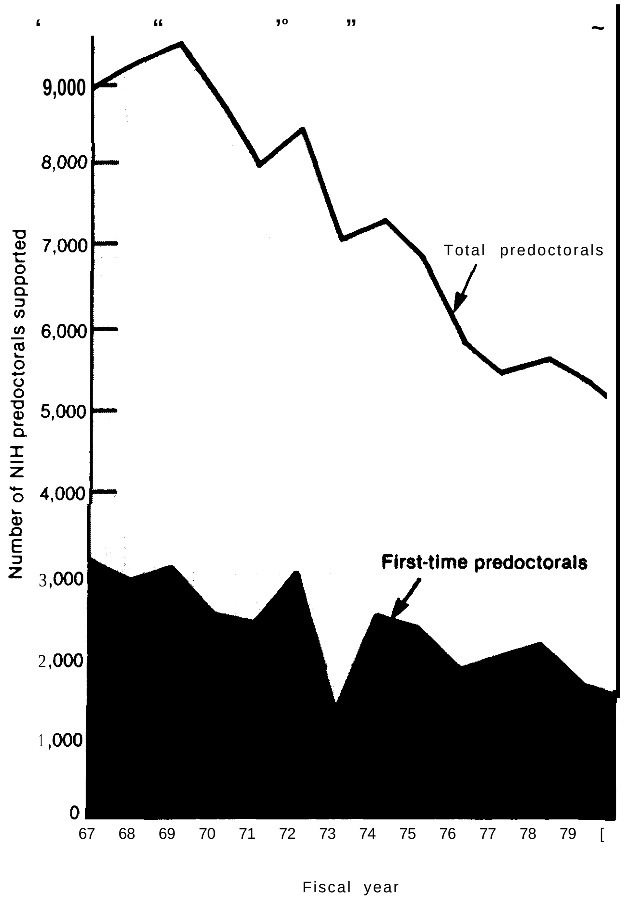
[6] National Research Council, Office of Scientific and Engineering Personnel, ***Survey of Earned Doctorates,*** *1920-81.*

Figure A-2.— Distribution of Primary Sources of Support for Graduate Students Enrolled in Ph.D.-Granting Biomedical Science Departments, 1975 and 1981



SOURCE National Science Foundation, Survey of Graduate Science Students and Postdoctorals Computerized Data File, Washington, DC, 1973-83.

Figure A-3.— Number of Predoctoral Trainees and Fellows Supported by NIH, Fiscal Years 1967-80



SOURCE IOM Re~ort on Career *Achlevemenfs, 1984*

of every three Ph.D. recipients in health-related fields had received some NIH training support while in graduate school. [7]

Allocation of Resources Between Predoctoral and Postdoctoral Training

The tradition of postdoctoral training in the biomedical sciences is a long one, possibly because NIH training programs are the oldest of their kind. The biomedical research system shows great sensitivity to the supply and demand for individuals in both groups. The amount of support available for postdoctoral v. predoctoral training has a definite effect on the sup-

‘Institute of Medicine, *Report of a Study: The Career Achievements of NIH Predoctoral Trainees and Fellows* (Washington, DC: National Academy Press, 1984).

ply of manpower in the biomedical sciences. Starting in the early 1970s through 1981, the number of postdoctoral appointments increased 9 percent per year.' (See figure A-4.) During this same period, Ph.D. production was fairly constant. Most of the postdoctoral expansion has occurred in medical schools, which employ 65 percent of the postdoctoral scientists in biomedical sciences. In fact, most of the growth has been in the 20 largest universities. [8]

Steady growth in the postdoctoral population may be a combined result of an increase in the numbers of new Ph.D. recipients and an increase in the length of time spent in postdoctoral appointments. IOM believes that the prolongation of apprenticeship has been a major factor in the expansion of the postdoctoral pool in the biomedical sciences. *10* The reason for the extension of postdoctoral training is not clear. A 1976 survey revealed that more than 40 percent of the postdoctoral had extended their appointments because they were unable to find a desirable position .11 In 1981, the last year for which data was available, the National Research Council estimated that the postdoctoral group constituted 18 percent of the full-time equivalent bioscience research personnel in Ph.D.-granting universities. *[2]

A particularly unique system of assessment and feedback in the area of biomedical and behavioral research personnel needs was established through law in 1974 when Congress passed the NRSA Act. This Act mandated that the National Academy of Sciences:

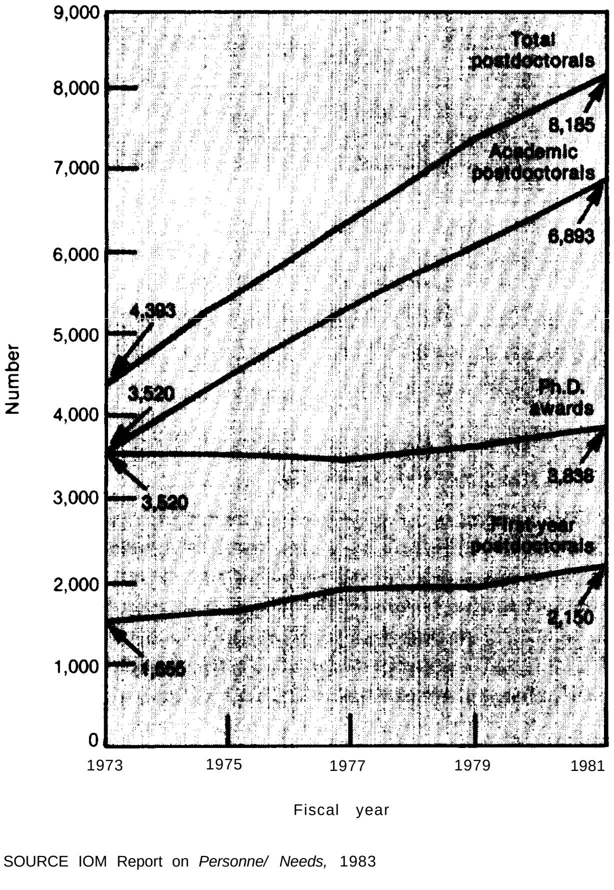
> . . . establish (A) the Nation's overall need for biomedical and behavioral research personnel (B) the subject areas in which such personnel are needed and the number of such personnel in each such area, and (C) the kinds and extent of training which should be provided such personnel. 13

In 197'5, the committee on a study of National Needs for Biomedical and Behavioral Research Personnel was formed under the aegis of the Commission on Human Resources, and later transferred to IOM. During its first 9 years, the committee published seven reports projecting the near-term demand for research personnel in biomedical and behavioral research.

The potential influence of this committee is impressive, as it is mandated to make recommendations to the Federal Government on the size of federally sponsored training programs for biomedical and behavioral scientists. It also makes recommendations for allocation of traineeships between predoctoral and postdoctoral students. To a large degree, the agencies have been responsive to these recommendations. The discrepancy between the level of support recommended by IOM and the actual funding level set by NIH has been small in recent years. Decisions regarding distribution of traineeships and fellowships, however, are left to the agency.

In recent reports (1981 and 1983), the committee has recommended that the agencies change the allocation of training grants from predominantly predoctoral training to predominantly postdoctoral. This recommendation was made in response to the growth of the

Figure A-4.— Estimated Growth in the Numbers of Ph.D. Awards, Academic Postdoctoral Appointments, and First"Year Postdoctoral Apppointments in the Biomedical Sciences, 1973-81



SOURCE IOM Report on *Personne/ Needs,* 1983

[8]Institute of Medicine, *Personnel Needs* (Washington, DC: National Academy Press, 1983).

[9]National Science Foundation, *Academic Science: R&D Funds 1975-1983,* Surveys of Science Resource Series (Washington, DC: U.S. Government Printing Office (annual)).

[10]Institute of *Medicine, Personnel Needs,* op. cit., p. 60.

[11]P. E, Coggeshall, et al., "Changing Postdoctoral Career Patterns for Biomedical Scientists, " ***Science, vol.*** *202, Nov. 3, 1978,* pp. 487-493.

12 National Research Council, *Postdoctoral Appointments and Disappointments* (Washington, DC: National Academy Press, 1981).

[13]US Congress, Title I of the National Research Act of 1974 (public Law 93-348), Section 473.

predoctoral population that occurred in the 1970s. The higher levels of Federal support for predoctoral training relative to levels of support for postdoctoral training which occurred in the 1970s contributed, in part, to the current slight surplus of biomedical Ph.D.s.

Harrison Shun, former Chairman of the Commission on Human Resources of the National Academy of Sciences, believes that the agencies should use their ability to shift funds quickly between predoctoral and postdoctoral support as a means of responding to a fluctuating job market. Postdoctoral funds can be increased when the supply of new Ph.D.s is high and demand is low; when supply is insufficient to meet demand, funds can be shifted the other way, towards more predoctoral support. This "fine-tuning" mechanism can work only if the supply of traineeships is controlled and steady .14

Demographics and Employment Outlooks for the Biomedical Ph.D.

The number of doctorate degrees awarded annually to bioscientists has been relatively constant since 1972. Bioscience baccalaureate degrees have been declining since 1976, and bioscience graduate enrollments peaked in 1978. In the long term, the attrition rate from the active pool of researchers will increase in the 1990s as the population ages, creating more academic positions. If graduate school enrollments continue to decline as the size of the college-age population declines, there could be a small decline of Ph.D. output in the late 1980s and 1990s. If this decline does, in fact, occur, there could be a temporary shortage of biomedical research personnel in the next decade.

The key **factors influencing potential shortages or surpluses** in this market are Federal funding for biomedical research, and graduate and medical school enrollments. If Congress continues to appropriate a steady level of funding to NIH, then, in a sense, the demand is set. Should the Federal Government suddenly increase or decrease its level of research support in the biomedical sciences, shortages or surpluses could occur.

The total biomedical Ph.D. labor force approached 70,000 in 1981. Half of these individuals were employed in academic institutions whose population has been growing at a rate of 4 percent per year. Employment in the industrial sector has been growing at a rate of 8.5 percent and self-employment at a rate of 24.7 percent (see table A-1).

Next to academia, the industrial sector is the second largest employer of biomedical scientists. Most biomedical Ph.D.s in industry are employed by chemical and pharmaceutical manufacturers. Recently, the biotechnology industry has shown rapid growth, and it is possible that some areas of commercial biotechnology may experience temporary shortages, as investigators attempt to catch up with the latest developments in a new field. A collaborative survey of biotechnology firms conducted by IOM and the Office of Technology Assessment in 1983 revealed that one-third of the respondents had experienced shortages in one or more specialties. The three specialties most often cited were bioprocess engineering, recombinant DNA molecular genetics, and gene synthesis. '5

Emerging fields will experience temporary shortages of trained personnel as new research opportunities become available. It is the view of some that the postdoctoral pool will be the critical element in ensuring an efficient and timely transition to steady-state supply, for postdoctoral are the most skilled in research methods and problem-solving and can most easily adapt to new concepts and new tools.

Clinical Biomedical Research Personnel [M.D.s]

The application of scientific advances to maintain good health and prevent and treat disease is the goal of *clinical*, as opposed to *basic* biomedical research. For the purposes of this report, clinical investigation includes research on: 1) patients or samples derived from patients as part of a study of the causes, mechanisms, diagnosis, treatment, prevention, and control of disease; or 2) research on animals by scientists identifiable as clinical investigators on the basis of other work.[16]

In general, clinical investigation requires the participation of an investigator trained in the clinical sciences and possessing a degree in medicine (M. D., D. V. M., D. D. M., D.O.). It is usually conducted by physician-investigators working in a clinical department of a medical school or in a clinical division of an institute. In general, clinical research is applied research, intended to ameliorate disease in the near term. Traditionally, it is the clinical researcher who applies the scientific and technological skills acquired through basic research to the vital tasks of medicine.

Both basic and clinical biomedical research personnel are critical to the biomedical research endeavor because of the skills and perspectives they bring to their

14 Harrison Shun, "The Ph.D. Employment Cycle—Damping the Swings, " ***The National Research Council in*** *1978: Current Issues and Studies* (Washington, DC: National Academy of Sciences, 1978), pp. 149-163.

[15]U.S. Congress, Office of Technology Assessment, ***Commercial Biotechnology: An International Analysis*** (Washington, DC: U.S. Government Printing Office, January 1984).

[16]This definition is the one adopted by the Committee on National Needs for Biomedical and Behavioral Research Personnel of the Institute of Medicine, National Academy of Sciences.

Table A-1 .—Current Trends in Supply/Demand Indicators for Biomedical Science Ph.D.s

	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):										
a PH. D. production	3515	3.578	3,465	3,516	3644	3823	3,838	1. 5%	o 4%	54
b Percent of Ph. D s without specific employment prospects at time of graduation	6 4%	6 3%	7 .2%	6 O%	5 .2%	4.8%	5.5%	–2 4%	14 .6%	–o 2%
c Postdoctoral appointments	5,484	n/a	6,403	n/a	7419	n[a	8,185	6 9%	5 .0%[a]	450
d B A degrees awarded	50,493	52,642	51,783	49,701	47717	45106	41,476	–3 2%	–8 .O%	– 1,503
2. Demand indicators (R&D funding):										
a National expenditures for health-related R&D (1972$ bill)	$370	$3.81	$397	$4.13	$431	$4.48	$444	3 . 1%	–o 9%	$0123
b Biomedical science R&D expenditures m colleges and universities (1972 $, bill)	$119	$126	$127	$1.34	$135	$1.43	$149	3 8%	4 .2%	$005
c NIH research grant expenditures (1972 $, bill)	$0.897	$0.944	$100	$1.06	$1 17	S1. 20	$1 19	4 8%	–O 8%	$005
d Ph. D. faculty/student ratio[b]	0058	n/a	C. 056	n/a	O 063	0067 (est.)	n/a	2 .2%	6 3%	0002
3. *Labor force:*[d]										
a Total	40,698	n/a	55167	n/a	62590	n/a	69076	5 3%	5 1%	5063
b Academic (excluding postdoctorates)	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	2,272	n/a	2,798	6 2%	1 3%	141
t Nonprofit	1,221	n/a	1,544	n/a	1. 854	n/a	2083	9 3%	6090	144
g Self-employed	836	n/a	864	n/a	1 197	n/a	1860	14 .3%	24 7%	171
h Other (Including postdoctorates)[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	n/a	831	n/a	9 .7%	52
4. *Biomedical* enrollments:										
a Graduate	38314	39.322	39,260	43,787	43,378	42969	42,117	1 6%	– 2070	634
b Medical and dental schools	74,222	77,011	79,279	81,934	84,761	86502	88,254	2.9%	2 o%	2,339
c Estimated undergraduate	424.539	439,946	425,863	406,373	374,869	386,236	n/a	– 1 9%	3 o%	-7661
d Total biomedical graduate and undergraduate enrollment	537,075	556,279	544,402	532,094	503,008	515707	n/a	– 0 8%	2 5%	-4274

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

[b]Ratio of academically employed Ph D s t. a 4-year Weighted average of total graduate andundergraduateenrollments (WS) where $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$

[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 baccalaurate degrees awarded In year i + 2 (excluding health professions) B - 2 = total baccalaureate degrees awarded in year i + 2 C, = total undergraduate degree-c redit enrollment in year i (excluding first professional)

SOURCE Institute of Medicine *Personnel Needs and Training for Biomedical and Behavioral Research 1983* p 52

work, However, the training of, supply of, and demand for clinical investigators present different issues than those of basic biomedical research personnel.

Recruiting and Retaining Physicians for Research Careers

It is the view of many in the medical profession that the clinical investigator is the critical link between the laboratory bench and bedside, While the basic biomedical scientist is well versed in the processes and intricacies of individual biological subsystems, and may have better training in research methods and techniques, it is the clinician who sees the whole system and recognizes the clinical manifestations of the underlying disease process. Thus, research initiated by physician-investigators tends to be more health-related, in general, than that of Ph.D. biomedical scientists,

In recent years, there has been concern that the country is facing an insufficient supply of well-trained physician-researchers, as fewer medical school graduates enter research careers and apply for research funds. This prospect is of concern because of the expense of allowing a prolonged lag time between the acquisition of knowledge and technological skills, and their application to medical care.

Currently, NIH supports almost 90 percent of all postdoctoral training in clinical research. The number of physicians seeking research training has declined on average by more than 6 percent per year since 1975 while the number of medical school graduates has risen from 12,716 in 1975, to 16,347 in 1985.[17]18 According to NIH, 47 percent of 5,680 individuals seeking postdoctoral research training in 1975 were holders of clinical degrees. By 1980, only 36 percent of 5,321 individuals seeking postdoctoral training held clinical degrees. *9 NIH cites several possible reasons for the

[17]Institute of Medicine, *Personal Needs,* op.cit.

[18]Anne E. Crowley, et al., "Undergraduate Medical Education, " *Journal of the American Medical Association, vol. 254, No. 12,* Sept. 27, 1985, pp. 1565-1572.

"Thomas E. Malone, "Report on Recruiting and Retaining Physicians for Research Careers" (typescript), National Institutes of Health, 1983.

decline in the number of physicians seeking research training. Young physicians may be discouraged from entering research careers because of the increasing difficulty of staying current in two fields (clinical and research). There may be too little exposure to research in medical school because of the competing demands of an increasingly overloaded curriculum. Young physicians, incurring a high degree of indebtedness after medical school, may not be willing to face the traditionally lower pay of research positions versus practice.

At the same time that interest in research seems to be declining among medical students, demand for faculty in the clinical departments of medicine remains strong, possibly because of the increase in professional fee income as a growing source of revenue. Fishman and Jolly have noted that the expansion in the number of medical schools over the past *30* years led to a greater than 25-fold increase in the full-time clinical faculty at American medical centers.[20] As of 1982, IOM reported that the market opportunities for clinical investigators continued to be favorable: Medical school faculties are still growing and providing places for young physician-investigators interested in research careers.[21]

However, after more than **30 years of continuous growth, there** appears to be a decline in medical school enrollments that could continue as the college-age population declines. These declining enrollments could potentially reduce the demand for physician-investigators at medical schools, the principal employers of NIH-sponsored clinical researchers. Thus, although there is a recognized and widespread realization that the physician plays a critical role in clinical investigation, and current demand is fairly high, opportunities for this population could diminish.

Another factor that affects the demand for physician investigators relates to the sources of revenue for medical schools. The abundance of Federal support for biomedical research since World War II created a continuous demand for trained biomedical research personnel, and provided a sizable source of income for medical schools with active researchers on their faculties.

Although research funds are intended primarily for the conduct of research, they also enable medical schools to expand the size of their faculties, and support graduate students, research assistants, and fellows. Federal research support grew from 11 percent of medical school income in *1947* to nearly 30 percent in **1969.**[22] However, in recent years, this proportion has diminished, as medical schools rely increasingly on other sources of support. In 1983-84, Federal research funds comprised only 14.4 percent of medical schools' restricted revenues.[23] The uncertainty of relying on competitive grants as a source of revenue, combined with a larger population in competition for limited funds has led medical schools to seek more reliable and controllable sources of revenue. Funds from professional fee income have grown at an annual rate of 25 percent between 1968 and 1981.[24] The contribution of professional fee income to medical school revenues is now 32 percent of total funds as compared to 12.2 percent in 1970-71.[25] More recently, research funds have become available from nongovernmental sources. As Jolly and his colleagues note in their 1985 report on medical school finances:[26]

> The growth of private, nongovernmental funding for health research and development is a phenomenon of rather recent origin, It may owe a part of its growth to the investment tax credits legislated in the early 1980s for increases in research and development by industry and the rapid expansion of research investment by the pharmaceutical industry related to rDNA technology, a part of which involves medical school performers.

Effectiveness of Federal Programs

In 1984, IOM, in consultation with NIH, examined the extent to which NIH-supported graduate students have been successful in their pursuit of careers in biomedical research.[27] They reported that former NIH predoctorals have outperformed individuals receiving no direct NIH support in terms of several measures. More than two-thirds of the NIH-supported group completed their doctorates compared to less than 50 percent of those receiving no support. In addition, the NIH group were more likely to have received NIH postdoctoral support and become involved at later stages in their careers in NIH-sponsored activities. They were more likely to have applied for and received NIH research grants. Last, former NIH trainees have written more articles and have received more citations than their biomedical colleagues who received no support.

Establishing cause and effect in any program evaluation is difficult. The success of the NIH-supported group may be due to the assistance they received, but it might also be due to the higher levels of motivation and intelligence which caused them to be selected in the first place. If so, there was a selection bias from the start and this group might have achieved the various accomplishments without Federal support. Whether

[20] A. P. Fishman and H. Paul Jolly, "Ph. D.rs in Clinical Departmerits," *The Physiologist*, vol. 24, 1981, pp. 17-21.

[21] Institute of Medicine, *Personal Needs*, Op. cit.

[22] National Academy of Sciences, Institute of Medicine, *Costs of Education in Health Professions* (Washington, DC: National Academy Press, 1974).

[23] H. Paul Jolly, et al., "U.S. Medical School Finances," *Journal of the American Medical Association*, vol. *254*, No. 12, Sept. 27, 1985, pp. 1573-1581.

[24] Institute of Medicine, *Personal Needs*, op. cit.

[25] H. Paul Jolly, et al., "U.S. Medical School Finances," *Journal of the American Medical Association*, vol. *252*, *No.* 12, Sept. 28, 1984, pp. 1533-1541.

[26] Jolly, et al., 1985, op. cit., p. 1577.

[27] Institute of Medicine, *Career Achievements*, op. cit., 1984.

they would have been able to complete the Ph.D. without Federal financial assistance is the critical question. It appears that the likelihood of completion has, in fact, increased.

Summary

Consistent Federal support for biomedical research in terms of funding of research and training has produced both a substantial supply and demand for investigators. This has had a largely positive effect. It has created a steady-state system in which there have been no major surpluses or shortages of biomedical personnel, However, it is a large system that would be difficult to reduce in significant ways without major dislocations. Unlike many fields of science, there is an institutional feedback mechanism between NIH and IOM that ensures a periodic assessment of the status of biomedical research personnel. This represents, to some extent, informed decisionmaking in the implementation of research training programs. The current number of trainees is quite close to the number recommended by the IOM committee,

Virtually all biomedical investigators have completed training to the doctoral level. Nearly **60** percent of them go on to postdoctoral appointments, compared to 28 percent of the Ph.D. cohort in science and engineering in the aggregate. Allocation of Federal support to either predoctoral training or postdoctoral training is a method of fine-tuning that can potentially be used to control the supply of biomedical investigators. This mechanism is exploited only in the biomedical sciences.

There appears to be no short-term shortage of basic biomedical scientists, although there may be some temporary shortages of special personnel in biotechnology. As industry innovates in biotechnology, there will be temporary shortages of highly specialized biomedical research personnel, such as bioprocess engineers, molecular geneticists, and genetic engineers. In some areas of biomedical science, there may be a surplus of trained Ph.D. scientists. While some Ph.D. biomedical scientists may currently be having problems in obtaining academic appointments, there is evidence that the rate of growth in industrial employment and self-employment may partially compensate for the surplus. Academic employment has been increasing by more than 4 percent per year, industrial employment is increasing by 8 percent, and self-employment is growing the fastest, at nearly *25* percent. While the postdoctoral appointment has increasingly compensated for the lack of academic appointments, it is a short-term solution to the academic surplus that requires more extensive examination. Postdoctoral appointees, do, however, conduct significant and important research in U.S. research institutions.

There is, however, evidence that the Nation is facing a potential shortage of clinical investigators, as fewer physicians pursue research careers. As fewer physicians enter into research careers, the potential for a widening gap between the direction of basic biomedical research and the treatment of recognized disease states becomes greater. NIH has implemented fellowship programs to encourage medical students and new physicians to pursue research careers.

Table A.2.—Federal Manpower Legislation Pertaining to Biomedical and Medical Personnel

1930	*Ransdell Act:* created the National Institutes of Health.
1937	Amendments to the *Ransdell Act:* established the National Cancer Institute which established the first Federal biomedical research program.
1944	Amendments to the *Public Health Service Act:* grants authority to NIH for extramural research programs.
1963	***Hea/th Professionals Education Assistance Act:*** established matching grants to assist in the construction of teaching facilities for schools of medicine and health professions, in response to the aggregate physician supply concern. Initiated a student loan program.
1965	*Medicare/Medicaid:* created new demand for medical care, and further pushed the drive for increased biomedical research.
1965	Amendments to *Health Professionals Education Assistance Act:* extended the construction and student loan provisions of original act. Established grants to health professions schools that increase enrollments (cavitation).
1966	*Allied Health Professionals Personnel Training Act:* authorized establishment of a health professions student loan revolving fund.
1968	Health *Manpower Act:* extended the construction, basic and special improvement grants program, student loans, and scholarship programs. Institutional grants determined on a cavitation basis.
1971	*Comprehensive Health Manpower Training Act:* established four areas of authorization—construct ion grants for teaching and research facilities, cavitation grants with an emphasis on certain curricular components, student assistance, and computer technology health care demonstration programs.
1972	*Emergency Health Personnel Act* Amendments: Public Health Service and National Health Service Corps Scholarships were established with awards contingent on agreement to serve in a shortage area.
1974	*National Research Service Award Act:* abolished and consolidated previous research training authorities under the Public Health Service Act.
1976	Amendments to the ***Comprehensive Health Manpower Training Act:*** cavitation contingent on federally determined proportion of residencies in primary care.
1981	*Omnibus Reconciliation Act:* budget cuts in education in the health professions, elimination of cavitation grants.

SOURCE Office of Technology Assessment