

The derivation of these equations and their application to man have been discussed in detail by F. Berglund and M. Berlin in *Chemical Fallout: Current Research in Persistent Pesticides*, M. W. Miller and G. G. Berg, Eds. (Thomas, Springfield, Ill., 1969), pp. 258-268, and by T. W. Clarkson in *Critical Reviews of Toxicology* (Chemical Rubber, Cleveland, Ohio, 1972), vol. 1, issue 2, pp. 203-234. These equations were applied to estimate the body burden of methylmercury as follows: If t_1 is the number of days of ingestion of contaminated bread, the daily intake, m , is related to the total dose, D , by the expression:

$$m = D/t_1$$

and the body burden, B_{\max} , at the end of ingestion will be

$$B_{\max} = (D/kt_1) [1 - \exp(-kt_2)]$$

where t_2 is the latent period in days. The value of k was calculated from the published value of $T_{1/2}$ (76 days) from Miettinen's data from 15 volunteers. The values of t_1 and t_2 were obtained from interviews with the patients and are listed in Table 4. The value of D was estimated from the concentration of mercury in the patient's blood by means of (i) linear regression analysis of the data in Fig. 5, A and B [see (14)]; (ii) Miettinen's data [see (12)].

16. R. Von Burg and H. Rustam, unpublished data.

17. L. Amin-Zaki, S. Elhassani, M. A. Majaed, unpublished data.

18. It should be noted that concentrations of mercury in maternal and infant blood have not been corrected for hematocrit differences. It is known that in the rural population of Iraq the hematocrit of the newborn infant may be twice that of its mother. These differences in hematocrits may be of importance because of the observation that the ratio of human red blood cells to the concentration of methylmercury in the plasma is approximately 9:1.

19. Population statistics were obtained from *Annual Abstract of Statistics* (Central Statistical Organization, Ministry of Planning, Iraq, 1970).

Support of New Principal Investigators by NIH: 1966 to 1972

Rate of entry of investigators into the NIH research project grant system is analyzed.

Carl D. Douglass and John C. James

In recent years, the growth of funds for the support of the National Institutes of Health (NIH) extramural research projects has slowed, and there was actually a slight decline in funds appropriated for research in fiscal year 1970. Increases in funding during fiscal years 1971 and 1972, up substantially from the 1970 level, indicated a resumption of the slower pace of growth extending approximately from 1966 to 1972. Such a situation has caused some concern in the biomedical community as to whether recently graduated but well-qualified scientists, not previously established as principal investigators, could compete successfully for new research grants. In view of this, the testing of the assumption that "new blood" is continually being infused into the population of investigators being supported becomes especially important. Consequently we have undertaken an analysis of the rate at which new investigators are gaining their research support from the NIH through the traditional research project grant mechanism. During periods of little or no growth, it is still possible for new investigators to receive support from

NIH each year because of the turnover in the research grant system and the resulting availability of money to fund competing applications.

Each fiscal year there are three review cycles, in which new and competing renewal research grant applications are evaluated—first by the study sections, for scientific merit, and then by the National Advisory Councils, for policy consideration and relevance to the mission of a particular national institute. Approximately 70 percent of the grants awarded each year are noncompeting continuations, which are regarded as moral commitments since they represent the second, third, or further additional year of a project approved for a period of more than 1 year of grant support. These grants are classed as "noncompeting" and are funded without being resubmitted for competitive review because they fall within the approved project period. At the end of the project period, averaging about 3 years, the investigator may apply for a renewal of his research grant by submitting an application that will reenter the competition. Thus, both new and renewal applications are in

competition for funds remaining from payment of noncompeting grant awards.

A detailed analysis (1) of NIH extramural programs from 1960 to 1970 provides background for understanding variations in the NIH growth pattern. Although the amount of support in dollars steadily increased, there was a decline in total number of projects supported during the latter half of the decade. The reason for the decline in the total number of research projects is related to such factors as inflation; increasing commitments to large biomedical research complexes, called "centers"; increasing technological complexity, which increases the cost of research; increased indirect costs; and increasing levels of personnel costs in research grant budgets. All of these factors influence the level at which NIH can support new projects in scientifically and programmatically meritorious areas of research and, consequently, the rate at which well-trained scientists may enter the system and assume major responsibility for their own research. Moss (2) in a study of the applications presented to the June 1971 meeting of the National Advisory Heart and Lung Council, found that the applications of young scientists (under age 36) were approved at a higher rate than those of older, more established scientists.

The single largest NIH extramural grant program, that of investigator-initiated research projects, has been funded at levels ranging from \$341 to \$427 million annually since fiscal year 1966. Information on this program is shown in Table 1. The intent of our study was to measure the rate of entry of new principal investigators (PI's)

Dr. Douglass is deputy director of the Division of Research Grants and Dr. James is chief of the Research Analysis and Evaluation Branch, Division of Research Grants, National Institutes of Health, Bethesda, Maryland 20014.

Table 1. NIH research projects.

Fiscal year	Number of awards	Amount awarded (millions of dollars)
1966	11,482	342.8
1967	11,333	373.3
1968	10,571	379.1
1969	10,267	366.0
1970	9,140	341.3
1971	8,788	371.8
1972	9,123	427.6

into the research project grant system and to record some of their characteristics. For purposes of this analysis, "new PI" refers to a scientist who received his first NIH research grant between 1966 and 1972. Accordingly, "established investigator" refers to a scientist who was the PI of an NIH research grant prior to 1966.

We do not presume that the only mode of entry into the NIH-supported research grant system is through the investigator-initiated traditional research projects (hereafter referred to as "research projects"), although this is by far the predominant course. Other ways in which capable research scientists may become associated with the NIH-supported research programs in positions of responsibility are (i) as leaders on subprojects of larger types of grants such as program projects (for

research problems broad in scope or problems that require a multifaceted approach) or clinical research centers and (ii) as coinvestigators on research projects. Biomedical scientists seeking individual research support can also gain it through other NIH programs, although such opportunities are limited.

Specifically, only the new research project awards (contrasted to renewal or continuation awards) were analyzed. The results, however, are discussed in relation to the larger universe of all research projects. Since a new grant can be obtained by either an established or a new PI, records were searched back to the beginning of NIH grant support programs in order to classify all new awards. As a result, 6,371 new PI's among a total of 9,765 recipients of 11,251 new grants between 1966 and 1972 were identified. Table 2 compares the new group of investigators with those having grants prior to 1966. Between 1966 and 1972, 64 percent (7,155 of 11,251) of all new awards were received by the new PI's. This number takes into account multiple awards, averaging 1.12 new awards for each new PI during the period studied. The established PI's received fewer new awards, but averaged 1.20 new awards per individual.

These data clearly show that the new PI's have consistently competed suc-

Table 3. New NIH research project awards by fiscal year, with number and percent of first awards to new principal investigators (PI's).

Fiscal year	Total number of new awards	Awards to new PI's*	
		Number	Percent†
1966	1,910	1,072	56
1967	2,021	1,102	55
1968	1,393	766	55
1969	1,613	909	56
1970	1,118	664	59
1971	1,300	783	60
1972	1,896	1,075	57
Total	11,251	6,371	

* First award. † Percent of all new awards.

cessfully for a share of the fluctuating pool of funds available for competing awards from year to year. The awards to new investigators shown in Table 3, limited to the first award that each individual received and grouped according to the fiscal year of the first award, provide information about the number of new PI's entering the NIH research projects program year by year. As mentioned above, an even greater proportion of new awards is captured by the pool of new PI's when multiple new awards are considered. The relatively steady rate of entry of new scientists into the system, as permitted by the amount of funds available for competing applications, is demonstrated by these numbers. Although the actual number of new investigators who could be supported decreased between 1968 and 1971, when the total number of research projects declined and the amount of funds available for starting new grants was relatively limited, the proportions of new investigators did not change much.

Figure 1 shows the proportions of new and renewal awards in the competing sector for the entire period of 1966 to 1972. The 7155 new grants to new PI's, each one representing the start of a new research activity, amounted to 33 percent of all the competing awards for the period.

The proportion of new PI awards (10 percent) to all research project awards is shown in Fig. 2. Since the time span covered by the study was 7 years, many renewal awards and non-competing awards were also received by the new PI's later in the period.

These data may be reduced to the number of individuals receiving awards for any fiscal year. An examination of the number of new PI's year by year,

Table 2. New NIH research project grant awards to new and established principal investigators (PI's), fiscal years 1966 to 1972.

Recipient	Number of awards	Number of investigators	Average number of awards per investigator	Average amount per award (dollars)*	
				1967	1971
New PI's	7,155	6,371	1.12	30,700	35,500
Established PI's	4,096	3,394	1.20	35,200	40,100

* Data for these two fiscal years were chosen to illustrate typical average sizes of new grants.

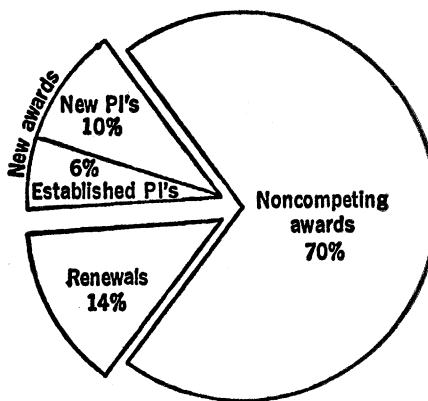
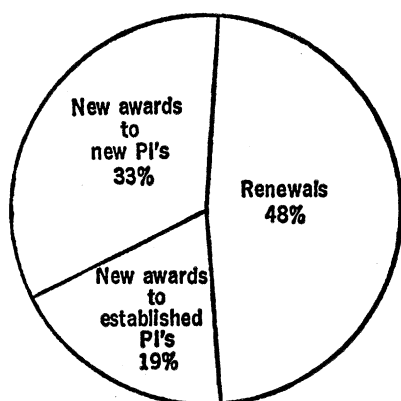


Fig. 1 (left). NIH competing research project awards, 1966 to 1972. Fig. 2 (right). NIH competing and noncompeting research project awards, 1966 to 1972.

compared to estimates of the total number of all PI's in the research project system (Table 4), provides another indication of the rate of entry of scientists into this research program. The variations in the number of new PI's from year to year can be attributed mainly to fluctuations in the amount of funds available for the award of competing grants. Thus, during the last seven fiscal years, a substantial number of new PI's, ranging from 8 to 13 percent of all PI's on research projects, have been supported each year for the first time. The upswing in fiscal year 1972 brings the level of new grant activity up to that characteristic of the 1966 to 1967 period, but the percentage of new PI's in 1972 is greater than the average (about 10 percent) for the 7-year period under study because of the smaller base of active grants generated in several years of decline. From 1966 to 1972, the total pool of supported PI's declined by about 20 percent, from approximately 10,250 to 8,150.

That decline is highlighted by the data presented in Table 5, which presents the estimated number of PI's no longer supported by research projects in a particular fiscal year for one reason or another. The investigators who lost this type of support may not have reapplied, may have had their grants terminated, or may have changed support mechanisms. The severity of the cutback in fiscal year 1970 is evident from this treatment of the data. If one considers that the number of active projects is a measure of the level of research activity, the trend depicted in Table 1 indicates that the amount of research being conducted by this mechanism of support has declined. It might appear that, if 10 percent of all PI's in the system each year are new and if the total number remains constant, there would be a complete turnover within 10 years. However, since all investigators must compete for renewals (some unsuccessfully), it is obvious that the pool is enriched, but not wholly replaced, by new PI's in a decade. The flux in the system indicated by the results of this study suggests that there is a continual need to produce trained biomedical scientists in order to maintain the vigor of the health research enterprise. The entry of approximately 1000 new PI's each year, under the present funding rates for all new applications, would require 4000 or more applicants for new grants yearly.

Characteristics of New PI's

Selected characteristics of new PI's have been analyzed to provide information about their age at the time their first award was received, their sex, degrees held, and the time lapse between their latest academic or professional degree and the beginning of the first grant. Sex and degrees held were determined for all of the new investigators in the study, while the other characteristics were taken from a random sample (665 individuals) of the 6371 new PI's from 1966 to 1972. A total of 604 individuals in the sample were either M.D.'s or Ph.D.'s, and the relative proportions of these two groups

Table 4. Number of new principal investigators (PI's) per year compared to estimates of the number of all PI's on NIH research projects.

Fiscal year	Total number of PI's	New PI's	
		Number	Percent
1966	10,253	1,072	10.5
1967	10,119	1,102	10.9
1968	9,438	766	8.1
1969	9,167	909	9.9
1970	8,161	664	8.1
1971	7,850	783	10.0
1972	8,146	1,075	13.2

Table 5. Number and percent of principal investigators (PI's) no longer supported as leaders of research projects.

Fiscal year	PI's no longer supported as leaders of research projects	
	Number	Percent*
1967	1236	12.1
1968	1447	14.3
1969	1180	12.5
1970	1670	18.2
1971	1094	13.4
1972	779	9.9

* Based upon estimated number of PI's in research project grant system at beginning of year.

Table 6. Sex of new principal investigators (PI's).

Fiscal year	Number of new PI's	Female new PI's	
		Number	Percent
1966	1072	66	6.2
1967	1102	68	6.2
1968	766	54	7.0
1969	909	65	7.2
1970	664	48	7.2
1971	783	57	7.3
1972	1075	87	8.1

closely approximated those in the population of 6371 investigators.

Approximately 54 percent of the Ph.D.'s in the sample were under age 35, and 75 percent were under age 40 at the start of their first grant. For M.D.'s the age was higher. Only 28 percent of the M.D.'s received their first grant when they were under age 35, while 70 percent were under age 40. The median age at the time of the first grant was 34 for Ph.D.'s, compared to 37 for the M.D.'s in the sample.

Another characteristic taken from the sample was the time elapsed between the date a research investigator received his professional or academic degree and the starting date of his first grant. Approximately 64 percent of the Ph.D.'s in the sample had received their first grant within 6 years, compared to about 8 percent of the M.D.'s within the same interval of time. The median time elapsed was approximately 5 years for Ph.D.'s and 11 years for M.D.'s. Internship and residency requirements no doubt contributed to this difference. Another possible reason for the delay for M.D.'s is the time required for the accumulation of research experience, which the Ph.D. acquires as part of his doctoral training. Planning for future research efforts must take into account the relatively long period of time between the beginning of graduate training or health professional training and the maturing of the trained person to the point where he or she is competent to receive a research grant. The median for this overall period of time (pre-doctoral plus postdoctoral) is probably at least 10 years for Ph.D.'s. The NIH's experience with M.D.'s over the past 7 years suggests a median of nearly 15 years from the beginning of medical school to the beginning of the first research grant.

Data concerning sex of the grantees was obtained because of the considerable interest in knowing the success rate of women scientists in the competition for research grants. With respect to the percentage of women among the new PI's, data (Table 6) show a slight upward trend. A greater increase in both number and proportion of awards to women occurred in fiscal year 1972.

From another study (3) dealing with the sex of PI's, it was found that, between fiscal years 1967 and 1971, the proportion of women among all applicants for new research project grants ranged from 5.7 to 7.2 percent. Considering this, the trend shown in Table 6 suggests an important relation be-

Table 7. Degrees held by new principal investigators on NIH research projects, fiscal years 1966 to 1972.

Degree	1966		1967		1968		1969		1970		1971		1972	
	Num- ber	Per- cent	Num- ber	Per- cent	Num- ber	Per- cent	Num- ber	Per- cent	Num- ber	Per- cent	Num- ber	Per- cent	Num- ber	Per- cent
Ph.D.	515	48.0	602	54.7	427	55.7	547	60.2	414	62.3	501	64.0	712	66.2
M.D.	441	41.1	384	34.9	251	32.7	279	30.7	199	30.0	221	28.2	274	25.5
Ph.D. and M.D.	30	2.8	39	3.5	39	5.1	46	5.1	26	3.9	31	4.0	46	4.3
Ph.D. and other health professional degree	9	0.8	17	1.5	10	1.3	14	1.5	9	1.4	8	1.0	19	1.8
D.D.S.	32	3.0	13	1.2	12	1.6	6	0.7	1	0.2	5	0.6	5	0.5
D.V.M.	13	1.2	6	0.5	9	1.2	4	0.4	5	0.8	6	0.8	4	0.4
NEC*	32	3.0	41	3.7	18	2.4	13	1.4	10	1.5	11	1.4	15	1.4
Total	1072	99.9	1102	100.0	766	100.0	909	100.0	664	100.1	783	100.0	1075	100.1

* Not elsewhere classified. Includes M.S., B.S., paramedical, engineering, other professional degrees, and principal investigators not identified by degree.

tween the rate of application of women for new research project grants and their rate of success in receiving awards. Kaufman's study (3) also shows that the approval rates of research project applications from male and female investigators do not differ significantly.

An analysis of the degrees held by new PI's (Table 7) shows a steady increase in the proportion of Ph.D.'s and a steady decline in the proportion of M.D.'s. Analyses of the degrees held by PI's of all research projects and of the degrees held by all applicants for research project grants have shown the same general trends. In 1966, Ph.D.'s accounted for 48 percent of all competing applications and 49 percent of the grants, while M.D.'s submitted 41 percent of the applications and received 39 percent of the grants. In 1972, by contrast, 60 percent of the competing applications were from Ph.D.'s and 59 percent of the grants went to them, while M.D.'s accounted for only 29 percent of the applications and 32 percent of the grants. The transition in both cases was gradual. The smaller

proportion of M.D.'s applying for and initiating their own research projects is no doubt attributable to a number of factors, including national supply and demand. Physicians have more employment options than do most other biomedical scientists upon termination of their training, and other national demands for physicians place a strain upon the available manpower resources. However, another study in progress has shown that proportionately more M.D.'s are involved in research at large centers and in interdisciplinary projects, which have been funded at proportionately greater rates than traditional research projects within the last several years. These projects tend to be oriented toward categorical medical problems, which require the skills of M.D.'s more than those of Ph.D.'s.

Summary

In summary, our findings indicate that the research project grant programs of NIH have consistently provided opportunities for newly trained

scientists to receive support for biomedical research projects that they have initiated themselves. The system encourages progress in the biomedical sciences through the continuous influx of creative individuals who can explore their own research ideas, ideas that also correspond to the health research needs of the nation as reflected by the categorical missions of the institutes. Despite the decline (approximately 20 percent) in the total number of active research projects over the past 7 years, the proportion of new PI's among all recipients of new awards remained fairly constant from year to year. From 1966 to 1972, an average of 57 percent of all new research project awards were received by PI's entering the system for the first time, while an average of approximately 10 percent of all the PI's on research projects each year were new PI's being supported by NIH for the first time.

References

1. T. J. Kennedy, J. F. Sherman, R. W. Lamont-Havers, *Science* **175**, 599 (1972).
2. W. G. Moss, *ibid.*, p. 10.
3. A. A. Kaufman, unpublished manuscript.

NEWS AND COMMENT

White House Foes: Wiesner Target of Proposal to Cut M.I.T. Funds

In the last 2 years, highly placed White House staffers and perhaps the President himself, apparently considered cutting off federal research funds to the Massachusetts Institute of Technology as a political reprisal against its president, Jerome B. Wiesner.

The evidence for this consists of the texts of two White House memoranda, one referring to a prior presidential "directive" to cut M.I.T.'s money "in view of Wiesner's antidefense bias." The second, which was addressed to the President himself, discussed how to do this. The first was addressed to

presidential aides John Ehrlichman, Henry Kissinger, and George Shultz in 1971; the second was addressed to the President in 1972. However, the plan apparently came to nothing; M.I.T.'s federal research funds have increased steadily over the last 3 years.

Wiesner—who was President John F. Kennedy's Science Adviser and an ardent foe of the Nixon-backed antiballistic missile system—is also listed on the White House "enemies" list said to be drawn up by the office of Charles W. Colson. It is not known what, if any, connection there is between the enemies list and the Wiesner-M.I.T. memos. The memos' existence, at least,