Trends in Public Health Service Research grants D2
DRG HISTORY 1946 through 1952

TRENDS IN PUBLIC HEALTH SERVICE RESEARCH GRANTS
1946 - 1952

By

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INTRODUCTION [1]

It is not possible to measure adequately the accomplishments and significant results of research on a current basis. On the other hand, it is quite natural that those sharing responsibility for administration of a program of research grants-in-aid should attempt to take early inventory of the manner in which the funds are being used. It is for such reasons that one attempts to analyze Public Health Service research grants and seeks, through critical evaluation of the grants awarded since 1946, answers to many questions that are asked concerning the program.

This report will concern itself, then, with these various questions and with data assembled to resolve in part some of the problems raised. Are there detectable trends, for example, in the type of research supported; in the distribution of the funds by geographical area; or in the end use of the grants by type of expenditure? What is the contribution of the program to the development of scientific manpower, professional and non-professional? Are the allocations of funds by institution or by section of the country properly related to their research potential and may one conclude that Public Health Service research grants have materially affected this research potential in different parts of the country? Does the scientist supported by the Public Health Service have scientific freedom in the full connotation of the term, or does he find his research hampered or restricted by rules, curbs, or limitations? These are representative of the questions that naturally arise.

I. SCIENTIST'S FREEDOM IN USE OF PUBLIC HEALTH SERVICE GRANTS

The last question above is perhaps the most important--and certainly the one to which greatest attention has been given. Every effort has been made, throughout the operation of the program, to insure scientific freedom of the investigator. He is free to publish as he sees fit and to change his research without clearance if he finds new and more promising leads. He has almost complete budget freedom so long as he uses the funds for research purposes and expends them in accordance with local institution rules. Travel funds are used for any trips in connection with research business, other than foreign travel to international meetings. Progress reports are required only once a year and are used chiefly as the tool for evaluation of renewal applications for support. Title to equipment is vested in the grantee institution and remains with the institution upon termination of the grant. Such policy provisions have brought general agreement that the maximum freedom is provided that can be allowed under the project system. Grants of fluid funds to institutions might permit somewhat greater freedom but not necessarily so since many scientists believe that local institution rules to govern such funds would be at least as limiting as Public Health Service policy.

Whether the Public Health Service directs to any extent the research of the grantee depends upon the point of view or the definition of the word. The Public Health Service research grant is intended as support of the idea of the scientist and not as a contract with him for the purpose of carrying out research for the government. If one considers the allocation of funds by major interest fields as direction, however, he must admit then that there

1/ The authors wish to acknowledge the valuable assistance of Mr. Ray Wilding and Mrs. Lynda Cahoon, Division of Research Grants.

is a degree of control and direction. The earmarking of funds for the national blood program of research, for radiation sickness studies, for rheumatic fever studies, and for other similar projects in which the Public Health Service had a particular interest, could be called "control." On the other hand, even in these programs, the only direction given has been in the development with the grantees of protocols under which joint studies could be conducted by collaborating scientists to produce comparable and adequate data. Different plans have been developed to permit such agreements. In one joint investigation supported in 1946, 1947, and 1948, the desired control was obtained by having regular meetings of the collaborating investigators to permit exchange of information and conformance to an over-all plan developed by the participants. In a second study, supported by special appropriation in 1948 and concluded in 1950, formal protocol was developed by the investigators prior to initiation of the research with firm conditions governing controls, patient selection, and other aspects of the investigation. Because several programs came to be identified in 1950 as "defense programs," the Public Health Service went even farther in directing research in that investigators were in a few instances actually persuaded to undertake work considered essential. All such programs, however, have constituted a relatively small percentage of the research supported, the very great majority having been research initiated by the scientist.

It should not be assumed from this statement that no effort is made to determine what additional research needs stimulation. In order to assure proper balance and reasonably sound integration of the various portions of the programs into a sensible whole, staff members must collaborate in the conduct of analyses and studies to permit ready identification of neglected areas of research or aspects of a special problem. In addition, the reviewing consultants comprising Study Sections and National Advisory Councils accept responsibility for reviewing their own special fields and for encouraging initiation of additional research where indicated. Such action by staff and consultants does not violate the spirit of Public Health Service policy of non-interference with the scientist. The objective is most often accomplished by facilitating the work of an investigator already working in the area needing stimulation, or by sponsoring symposia that afford the grantees and others opportunity to exchange ideas and thereby stimulate each other. It is safe to conclude therefore from these pertinent parts of governing policy and practice that the scientist conducting research with Public Health Service assistance does have essentially complete scientific freedom.

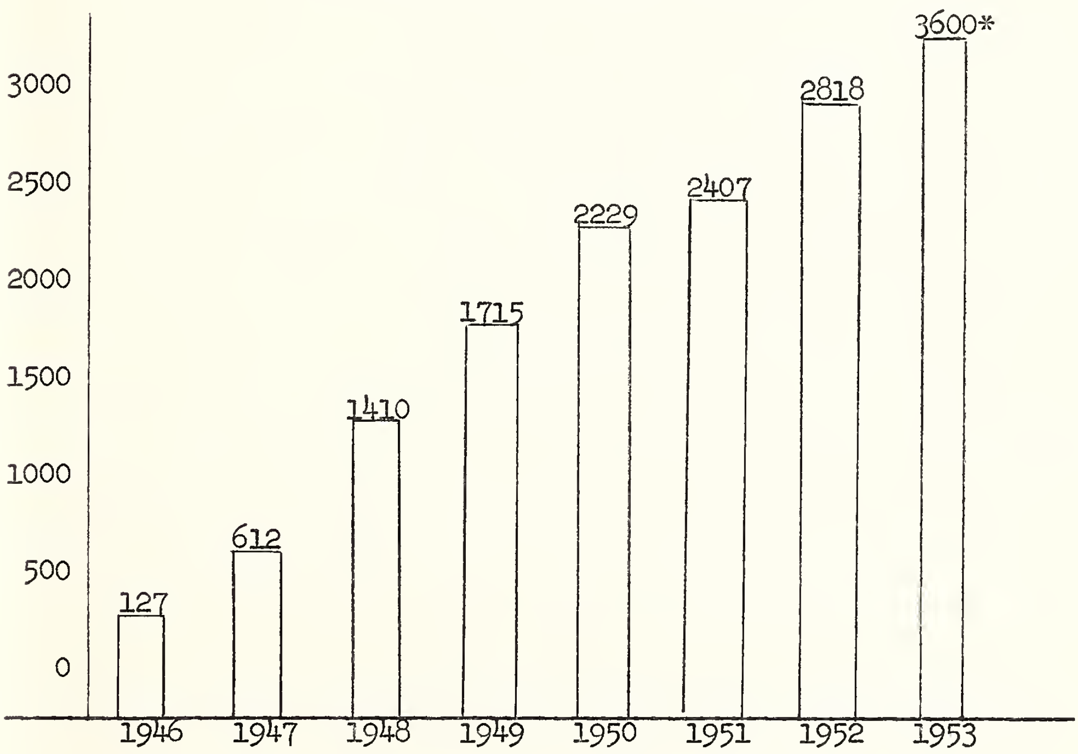
II. TRENDS IN TYPES OF RESEARCH SUPPORTED

From the beginning of the expanded program in 1946 any research related to health has been eligible for support. The distribution of funds among various fields has therefore depended to a considerable extent upon the types of proposals received. The projects transferred from the Office of Scientific Research and Development in 1946 were largely applied projects started during the war. Several fields were notably active then - particularly the evaluation of penicillin therapy of syphilis and the synthesis and testing of antimalarial drugs.

The Nation's scientists, however, were weary of war research and there was soon a flood of applications in many broad fields of research with a heavy emphasis on fundamental studies. The steady increase in applications of all types received is shown in Chart I.

CHART I

Applications received 1946-1953



* Estimated on basis of receipts to date.

An enthusiastic Congress increased the appropriations for research grants from $780,158 in 1946 to $20,468,000 in 1953. As public interest in medical research grew, there was public pressure for emphasizing new fields. In order to stimulate research on some of the major causes of death and disability, Congress established categorical institutes in special fields, each with a grants program and a council. The growth in size and number of categories of appropriations is shown in Table I.

TABLE I

NIH [1] RESEARCH GRANTS APPROPRIATIONS BY FISCAL YEAR

Field	1945	1946	1947	1948	1949	1950	1951	1952	1953
Cancer	85,030	76,900	515,000	2,599,635	3,300,000	2,600,000	3,129,079	3,100,000	4,920,000
General		703,258	2,922,280	5,901,163	7,025,492	5,570,000	5,108,645	4,305,000	4,255,000
Mental Health				373,665	546,000	794,000	1,198,628	1,663,000	1,662,000
Heart						3,820,000	4,327,479	4,809,000	5,150,000
Dental						200,000	218,400	221,000	221,000
Arth. & Met. Dis.							695,395	1,345,000	1,345,000
Neur. Dis. & Blind.							342,708	1,015,000	965,000
Microb.							1,353,794	1,950,000	1,950,000
Total	85,030	780,158	3,437,280	8,874,463	10,871,492	12,984,000	16,374,128	18,408,000	20,468,000

1/ National Institutes of Health--Bureau of the Public Health Service responsible for the administration of the research grants program.

Naturally, this earmarking of funds has exerted a powerful influence on the pattern of research effort. As each categorical program got under way, investigators already working in the field were able to undertake additional research by securing necessary assistants, equipment, and supplies. Other investigators and laboratories expanded their research in order to enter these fields, and men in the training stage were attracted into them by availability of funds and the activities in the laboratories of their sponsors.

Several factors have operated to make possible a general growth of medical research. There has been some increase in funds not earmarked for specific fields, not only in the Public Health Service but also in other granting agencies. Of greater importance, however, has been the wisdom and vision of the categorical programs which have supported broad fundamental studies as well as those specific practical investigations which could be expected to yield immediately applicable results.

The increased availability of funds in the categorical fields resulted in such a rapid growth of research that a number of new journals had to be established. Some scientists had been apprehensive lest this extensive categorization in the medical field might distort the distribution of research effort and force investigators into a few narrow fields of applied research but these fears did not prove justified. An examination of medical publications discloses increased activity in nearly all fields.

There are a few areas in which research has declined, but these exceptions appear to be due to the solution of the outstanding practical problems with a consequent loss of interest on the part of the investigators. Research on syphilis is a good example. At the beginning of the program, syphilis was a major research area with many active projects requiring large amounts of money and the intensive efforts of a Syphilis Study Section. Now there is a mere handful of projects, the Study Section has been abolished, and the early stages of syphilis are becoming so rare that medical schools find it difficult to locate teaching material. Large laboratories which devoted full time to research in syphilis have now reduced this type of research and are entering new fields.

It is interesting to note the emergence of new patterns of research organization in the medical schools. Departmental barriers are breaking down many of the projects now involving several departments. New multi-discipline departments are being created. One finds professors of chemistry in departments of internal medicine. Departments of anatomy are actively investigating problems of physiology or pharmacology. Perhaps the most striking changes are appearing in the clinical departments, where the level of research activity is rising rapidly and is changing in nature. Fundamental studies of great importance are originating in these departments. These changes in the clinical area are made possible not only by employing basic scientists but also by training clinicians in the basic disciplines. This trend is particularly noticeable in our fellowship program where the percentage of physicians applying for fellowships in the basic sciences is rising rapidly.

Thus, the increase of medical research has been generalized, although some few fields have faded from importance and some have remained inactive for lack of trained men or lack of tools or ideas. The question is repeatedly asked, "When will we reach the saturation point?" This question is hard to answer since the thing to be saturated - the research potential - keeps growing. In order to investigate the magnitude of this growth we have brought the Reynolds - Price study[1] up to date and explored several new applications of it.

III. MEDICAL RESEARCH POTENTIAL AND PUBLIC HEALTH SERVICE GRANTS

A. Growth in Medical Research Potential

The Reynolds-Price index of research potential was originally rather complex and equated listings in American Men of Science, research publications, residencies, internships, fellowships, and advanced degrees. In the present study it was found that the index could be obtained by using only two of the above factors, namely, American Men of Science listings and publications. The original study has been recalculated on the new basis so that the two studies can be compared.

Fortunately there has been an opportunity to validate the index in part. The Office of Defense Mobilization circularized every faculty member in all medical schools in connection with the Doctor Draft and obtained information as to the man hours spent on research. These results were tabulated and were compared with our American Men of Science listings. A high degree of correlation was found ($r = .920$). The Office of Education maintains a roster of scientists in various fields. We were able to obtain an analysis of distribution of scientists by field of specialization and by State. Compared to our American Men of Science listings this analysis showed an even higher degree of correlation ($r = .976$). We may assume therefore that our measure of the distribution of trained medical research manpower is reasonably accurate.

What does the analysis show? It demonstrates a rapid growth of the manpower pool, especially in the West. The 1944 edition of American Men of Science lists 5665 medical scientists in non-federal institutions. In the 1949 edition, the listings had increased 59% to a total of 9008. The distribution by geographical areas is shown in Table II.

1/ Federal Support of Medical Research Through the Public Health Service, by Frank W. Reynolds and David E. Price, American Scientist, 1949, Vol. 37, No. 4.

TABLE II.

American Men of Science Listings of Non-Federal Medical Scientists (1944 & 1949)

Geographical Area	Number in 1944 Edition	Number in 1949 Edition	Change Number	Change Percent
New England	651	950	+ 299	+ 46
Middle Atlantic	1556	2381	+ 825	+ 53
South Atlantic	712	1032	+ 320	+ 44.9
East North Central	1109	1780	+ 671	+ 60.5
East South Central	196	254	+ 58	+ 29.6
West North Central	610	1015	+ 405	+ 66.4
West South Central	266	430	+ 164	+ 61.7
Mountain	117	222	+ 105	+ 89.7
Pacific	448	944	+ 496	+110.7
Total	5665	9008	+3343	

The area showing the least increase (29.6% over 1944) was the East South Central (Kentucky, Tennessee, Mississippi, and Alabama); the area of greatest increase (110.7%) was the Pacific (Washington, Oregon, and California). The possibility that this increase might be due to a change in the standards of American Men of Science was explored with the editors, who stated that the standards had not been altered. The listings are developed with the guidance of the national professional scientific societies. Since society membership, publications, academic position, and scientific reputation are all considered, men listed may be assumed to meet certain minimum standards and to constitute potential researchers.

It is well known, however, that even though the Ph.D. candidate must demonstrate some research ability in his thesis work, he may lose interest in research or may have so many other duties as to be unable to continue his research in an academic or other position. The M.D. with his training directed primarily toward the practice of medicine rather than research is not always trained in research even though he may be a renowned professor.

It is necessary, therefore, to adjust the manpower figures by taking into account such factors as research ability, research interest, research opportunity, and research facilities. These factors cannot readily be measured directly, but since they play an important role in determining whether a man publishes research papers they can be measured indirectly by enumeration of scientific publications. This measurement applied to a single investigator or a single scientific discipline could be quite misleading but when taken in the aggregate appears to be reasonably sound. It is believed that the accuracy of the method is increased by limiting the enumeration to the highly reputable national scientific periodicals. Accordingly, 53 such periodicals were analyzed and the 13,911 articles were tabulated according to institution of origin. The results are summarized in Table III, which shows the comparative percentages in 1939-40 and 1949-50.

TABLE III.

Geographical Origin of Articles Appearing in Leading Medical Scientific Periodicals

Geographical Area	Articles Appearing in 50 Periodicals 1939-1940*(%)	Articles Appearing in 53 Periodicals 1949-1950 (%)
New England	13.54	13.29
Middle Atlantic	31.28	27.80
South Atlantic	10.31	10.52
East North Central	19.88	21.18
East South Central	3.29	2.37
West North Central	9.43	8.61
West South Central	3.93	4.52
Mountain	1.20	2.01
Pacific	7.10	9.69

* These figures are taken from the Reynolds-Price study. The years 1939-40 were chosen rather than 44-45 because many scientists were absent in the Armed Services during the war and the schedules of a number of the periodicals were altered.

When the distribution of sources of publications is compared with the distribution of scientific manpower, it is noted that some areas appear more productive man for man than others. The ratio between % publications and % men varies from .82 in the less productive Mountain States to 1.26 in the New England States. When the ratio is determined for individual universities the variation is much more striking, being .14 for the lowest and 1.71 for the highest.

The decision as to what weight should be given to publications and to manpower must be arbitrary. Since Reynolds and Price gave equal weight we have done so in the present study, the index of research potential (R.P.) being determined by the formula $R.P. = \frac{\% \text{ Publications} + \% \text{ A.M.S. Listings}}{2}$.

The original Reynolds-Price index has been recalculated and is compared with the current study in Table IV. At first glance these figures on relative distribution of research potential do not seem impressive; but when one takes into account the rapid increase in manpower and facilities, the change in actual research potential is considerable, particularly in the West. Taking the manpower situation into account the Mountain and Pacific states have approximately doubled their actual research potential while their relative R.P. increased only .59% and 2.57%.

TABLE IV.

Geographical Distribution of Research Potential in Non-Federal Institutions

Area	R.P. 1939-1944	R.P. 1949-1950	Change
New England	12.51%	11.92%	- .59%
Middle Atlantic	29.37	27.12	-2.25
South Atlantic	11.44	10.99	- .45
East North Central	19.73	20.47	+ .74
East South Central	3.38	2.60	- .78
West North Central	10.10	9.94	- .10
West South Central	4.32	4.65	+ .33
Mountain	1.64	2.23	+ .59
Pacific	7.51	10.08	+2.57
Totals	100.00%	100.00%	0.00%

It is gratifying to observe the rapid development of medical research potential in nearly all medical schools. Institutions showing the most rapid growth are enumerated in Table V.

TABLE V.

Changes In Relative Medical Research Potential Between 1944 and 1949

Institution	Change	Institution	Change
Univ. of Utah	+ 375%	Bowman Gray	+ 87%
Univ. of Washington	+ 175%	U. of So. Calif.	+ 81%
Syracuse University	+ 139%	Boston University	+ 80%
Southwestern Med. Sch.	+ 138%	Med. Coll. of Ala.	+ 79%
Coll. of Med. Evangelists	+ 126%	U. of Indiana	+ 73%
New York Medical College	+ 100%	Tufts College	+ 70%
Emory University	+ 92%	U. of California	+ 66%

Despite the widespread establishment of new research centers, there remains a dense concentration of manpower and activity in a relatively few institutions. In order to examine the situation we have divided institutions having medical schools into groups of 10, arranged in descending order of research potential according to the first analysis, and have recorded the relative changes in Table VI. The growth rate in the smaller institutions is very striking. It is worth noting, too, that despite the fact that only about 60% of National Institutes of Health research grants go to medical schools, the research potential of these schools is outstripping the growth in all other non-Federal medical research organizations.

TABLE VI.

Changes in Relative Medical Research Potential in Institutions Having Medical Schools

Group	R.P. 1944	R.P. 1949	Change Actual	Change Proportional
1st ten	27.91	28.22	+ .31	+ 1%
2nd ten	14.38	15.94	+ 1.56	+11%
3rd ten	7.63	7.72	+ .09	+ 1%
4th ten	5.52	6.56	+ 1.04	+19%
5th ten	4.04	4.25	+ .21	+ 5%
6th ten	2.99	3.70	+ .71	+24%
7th ten	2.03	3.39	+ 1.36	+67%
last eight	.98	1.75	+ .77	+79%
Total	65.48	71.53	6.05	9%

B. Distribution of Public Health Service Research Grants

In the study carried out by Reynolds and Price in 1949, there was evidence of close correlation between the distribution of research potential and the distribution of grant funds. Similarly, the level of requests paralleled the level of awards in various geographic areas.

We find that the changes in research potential and in level of requests have been accompanied by corresponding changes in geographic distribution of funds so that close correlation still exists (See Charts 2 and 3).

One must remember, however, that the areas considered are large and that most areas contain weak as well as strong research institutions. Consequently, it is important to examine the distribution in relationship to the relative research strength if one is to learn whether the program favors the strong or encourages the weaker to grow. This has been attempted and the results are shown in Chart 4. From such a chart it seems obvious that the distribution has been reasonably equitable but that there is some tendency to award what appears to be a disproportionately large amount to the schools which already have large research programs. One must, however, exercise great caution in drawing sweeping conclusions as to equity of distribution. These large schools, as a result of having adequate support, are enabled to play a major part in training the new investigators now appearing in increasing numbers in the smaller schools. Furthermore, an examination of the facts shows that schools growing most rapidly in the research field are not those near the top of the list in the Reynolds-Price study.

When one compares the Reynolds-Price list with the present list, one notes that the University of Utah moved up 43 places; the University of Washington, 27 places; and Syracuse University, 24 places. In all, there were 11 schools mostly near the bottom which moved up more than 10 places in the list. We have therefore become curious as to whether National Institutes of Health grants might have played a part in these spectacular changes. We have found that on an average, those schools which moved up the list received somewhat more than their R.P. would justify during the early part of the program, while those schools which moved toward the bottom of the list received on the average somewhat less. Despite the average results there is such great variation that one must conclude that the National Institutes of Health grants program has not been the major factor in the rearrangement.

CHART 2

Comparison of Funds Requested with Research Potential

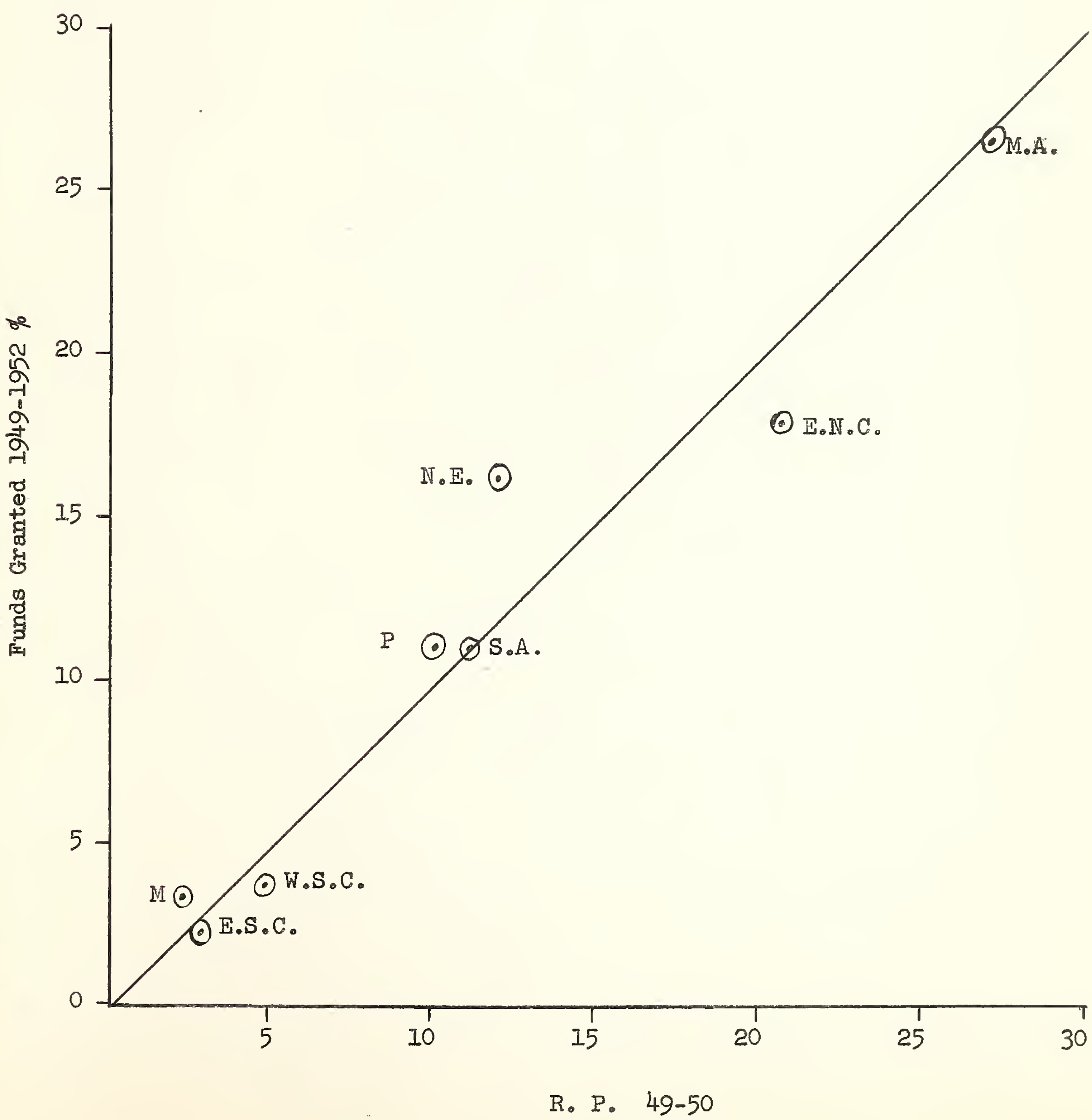


CHART 3

Comparison of Funds Requested with Funds Granted

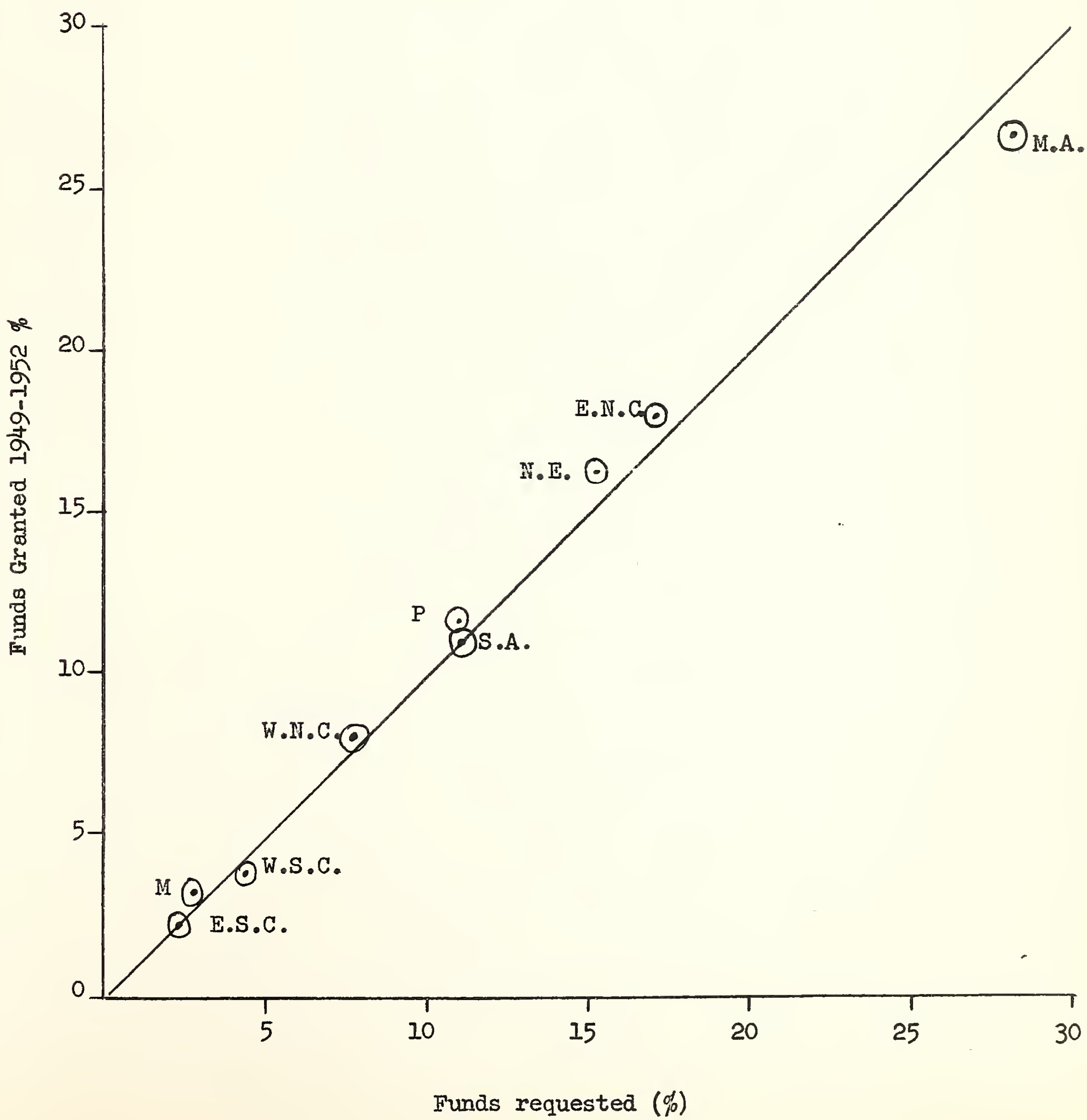
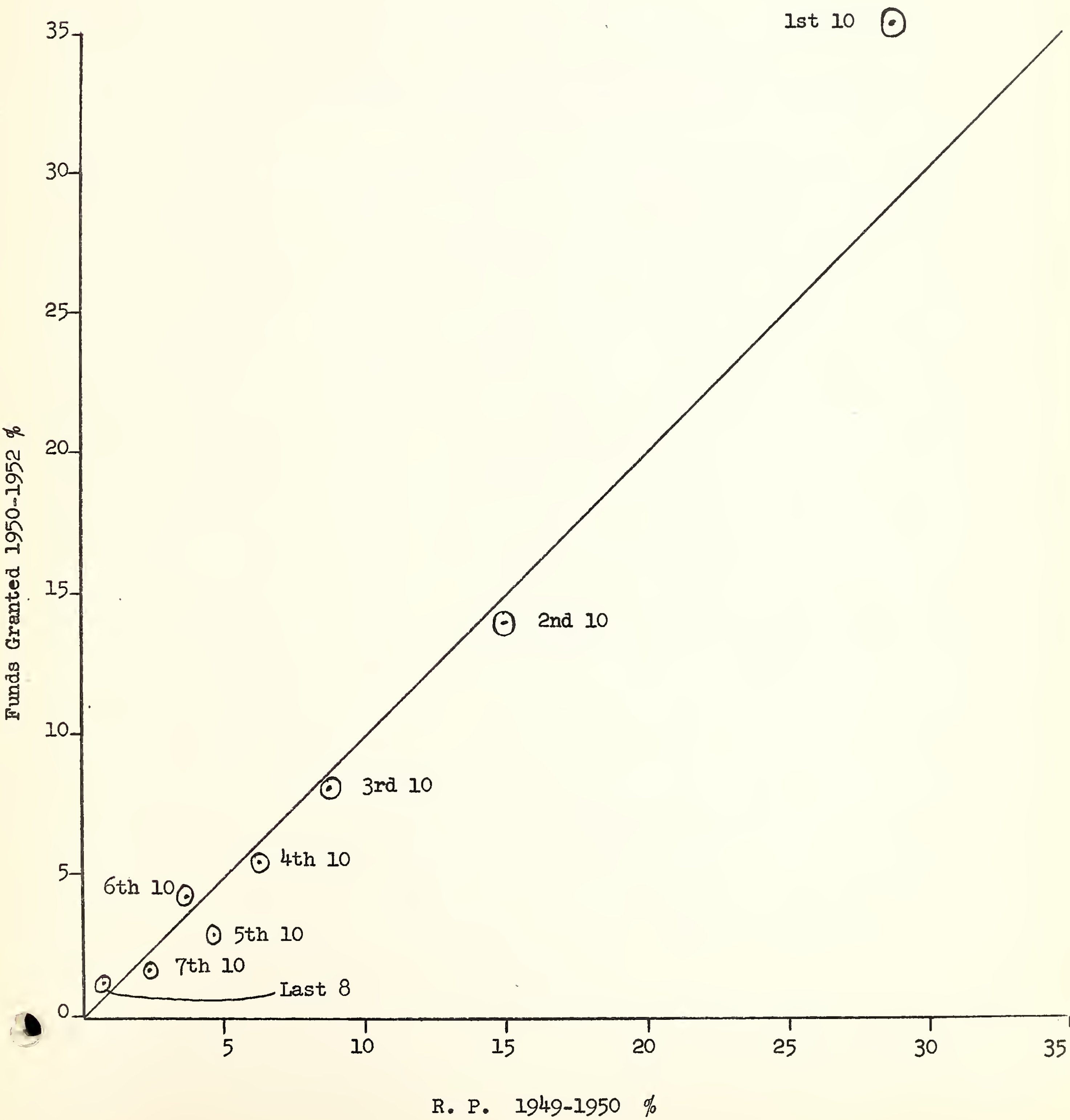
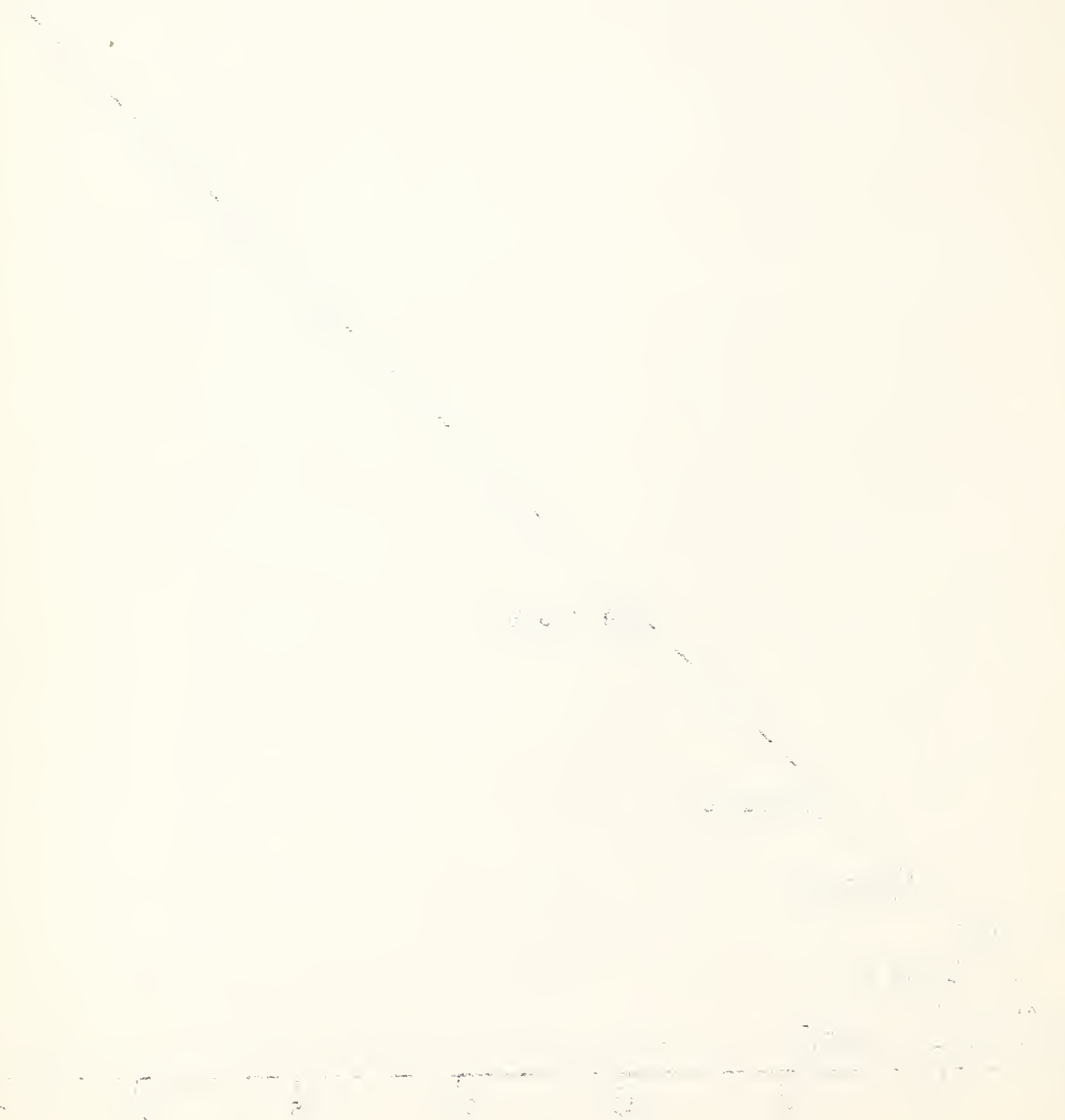


CHART 4

Comparison of Research Potential of Medical Schools
with Distribution of PHS Grants





We conclude that National Institutes of Health grant money has followed rather than produced the shifts of research potential. Backward institutions have evidently taken the initiative, provided places for additional competent investigators on their staffs, and subsequently sought and obtained grants to support the research of the new men. This tendency is reflected clearly in the approval rates on new applications from some of the weaker schools (See Table VII).

TABLE VII.

Approval Rates on New Applications, 1948 and 1952, by Groups of Institutions having Medical Schools

Groups of Schools	Approval Rate 1948	Approval Rate 1952	Change
1st 10	59.0%	55.1%	– 3.9%
2nd "	62.4	48.2	- 14.2
3rd "	48.1	56.9	+ 8.8
4th "	56.0	50.9	- 5.1
5th "	44.8	42.2	- 2.6
6th "	50.4	52.4	+ 2.0
7th "	19.0	34.0	+15.0
Last 8	38.8	30.3	– 8.5

IV. ACTUAL EXPENDITURE BY BUDGET CATEGORY

From the outset, the fiscal policy of the grants program has been made liberal and flexible in order that grantees might modify their expenditures in the light of changing needs. The budget approved when a grant is made may therefore be modified extensively by the grantee as the study progresses. One must accordingly study the final fiscal reports to learn how the money is actually spent.

In view of the extended discussions of budgets always encountered at Study Section and Council meetings and consequent questions about specific uses, we have analyzed the Expenditures Reports available for fiscal years 1947, 1949, and 1951. The results are summarized in Table VIII.

TABLE VIII.

BUDGET ITEM	% of Total 1947		1949		1951	
PERSONNEL						
Professional						
Prin. Investigator (Full time)	.358		1.034		.473	
Prin. Investigator (Part time)	1.610		1.003		.993	
Research Associate	4.625		5.989		7.537	
Research Assistant	8.653		14.265		15.032	
Research Fellow	2.704		4.304		4.121	
Other Professionals	6.278		7.140		6.956	
		24.228		33.735		35.114
Non-Professionals						
Nurses	5.898		1.119		.473	
Secretaries, Stenos., Typists	4.168		4.345		3.264	
Technicians & Other Non-Prof.	27.571		29.056		28.727	
		37.637		34.520		32.464
Soc. Sec., Annuities, Retirement	.212	.212	.204	.204	.668	.668
TOTAL PERSONNEL		62.077		68.459		68.246
SUPPLIES						
Animals	4.088		3.031		2.804	
Office	.510		.176		.945	
Laboratory	13.916		15.193		15.584	
TOTAL SUPPLIES		18.514		18.400		19.333
EQUIPMENT						
Apparatus (Items over $1,000 ea.)	2.939		2.116		2.450	
Apparatus (" under " ")	9.363		7.755		6.517	
Office	.556		.228		.150	
Rent & Repair	1.188		.266		.288	
TOTAL EQUIPMENT		14.046		10.365		9.405
TRAVEL						
Domestic	1.600		1.832		2.094	
Foreign	.060		.119		--	
TOTAL TRAVEL		1.666		1.951		2.094
OTHER						
Bed Cost	3.353		.581		.541	
Reprints, Publications	.127		.136		.199	
Miscl.	.223		.184		.201	
TOTAL OTHER		3.703		.901		.941
TOTAL		100%		100%		100%

The following general trends in the average expenditures are evident: (1) relative expenditures for professional personnel are increasing while those for non-professional personnel are decreasing; (2) supplies show little change; (3) equipment items show a steady decrease; (4) travel shows a slight increase; (5) "Other" costs, after an early abrupt drop, have stayed about the same. In order to present significant details, the budget categories will be discussed separately.

A. Personnel

Salaries for principal investigators, a favorite subject for discussion at meetings, constitute a very minor budget item, falling from 1.9% in 1947 to 1.4% in 1951. At such a level this would provide salary for less than 50 scientists in a $20,000,000 program - less than one per grantee medical school. Evidently the program serves largely to provide assistance to scientists whose salaries are paid from other sources. The major item (about 68% of the total budget) is salaries for subordinate personnel - both professional and non-professional.

It has been said that the National Institutes of Health fellowship program is largely buried in the personnel item of grant budgets. We have tried to explore this matter but find it impossible to give any firm figures because of such things as the variation in meaning of titles and the variation in the training element from one place to another. If one makes the bold assumption that 25% of all professional salaries except those of principal investigators represent research training, then in Fiscal 1953 the grants program would provide about $1,500,000 toward research training - a figure roughly equal to the fellowship program. One cannot escape the fact, however, that employees under grants have considerably less time and opportunity to obtain the broad training afforded regular fellows.

B. Supplies

This item remains almost constant at about 18%. Approximately one sixth goes for experimental animals and five sixths for laboratory supplies. The item for office supplies - another item often discussed at length - amounts to less than .2% of the total budget in 1951.

C. Equipment

The percentage spent for equipment has fallen steadily from 14% in 1947 to 9.4% in 1951. This trend would be expected as the laboratories become equipped and as more and more of the program comes to represent continuation projects. It is interesting to note that the office equipment item, always small, is becoming even smaller.

D. Travel

This item is edging up slowly despite the ban on foreign travel to international meetings but even at 2% does not appear at all excessive.

E. Other

The most interesting items here are bed costs and publication costs. Bed costs have declined from 3.3% in 1947 to .5% in 1951, even though the amount of clinical research has increased sharply. One wonders whether Council and Study Section interpretation of policy in this regard may not be excessively severe. Publication costs have increased slightly but will probably increase more as the financial plight of the journals becomes worse.

In 1947 the various geographic areas showed remarkable differences in the distribution between budget categories. Thus the Mountain States spent nearly 50% on equipment while the West South Central States spent over 75% on personnel. By 1951 these differences had largely disappeared so that the patterns are now fairly uniform across the country.

It would be of interest to trace trends in budget categories in large _versus_ small schools and in the various categorical programs so we prepared the necessary tables but found that early samples were too small to be reliable. When one ignores trends and looks only at 1951, one sees that although the differences are not great, the larger schools tend to spend more for personnel and supplies while the smaller schools tend to spend more for equipment. There are rather major differences between budget categories in the various scientific fields. Thus, in the Heart and Neurology programs the equipment item is high. In the Arthritis program, supplies cost 27% as contrasted to an average of 19%. The Mental Health program is unique in that nearly half of the total budget is for professional personnel and the total for personnel is 74% as compared with the average 68%.

TRENDS IN MEDICAL RESEARCH PUBLICATIONS

We have now discussed at some length various aspects of the growth of the National Institutes of Health research grants program and of the development of research potential. We have inquired into how the Study Sections and Councils have distributed the funds and how the grantees have spent them. It seems appropriate to end this report by examining what the taxpayer is getting in the way of research results.

Let us introduce this subject with the proper note of caution. We recognize that many years must pass before recent research results can be seen in their true perspective; therefore, we shall not recite a list of scientific accomplishments though the temptation is great. Instead, we shall examine only the relative volume of publications acknowledging National Institutes of Health support as compared to publications not carrying such acknowledgment.

For this study we analyzed 36 prominent national medical science journals for the years 1948 and 1951, recording the source of the article and the source of financial support.

In the first table (Table IX.), there is a summary of the source of articles. Where several sources were listed the article was assigned arbitrarily to one for purposes of the summary.

TABLE IX.

Sources of Publications in Medical Science

Source	1948	1951	Change
Universities & Colleges	65.71%	66.92%	+ 1.21%
Research Foundations	5.43	5.16	- .27
Hospitals	9.19	8.00	- 1.19
Commercial Laboratories	4.93	3.51	- 1.42
Government Laboratories	8.82	10.50	+ 1.68
Other	5.92	5.91	- .01

In the next table the source of acknowledged support is shown

TABLE X

Source of Financial Support Acknowledged in Medical Science Publications

Source of Support	1948	1951	Change
National Institutes of Health	9.48%	19.80%	+10.32%
Other Government Agencies	7.89	8.00	+ .11
Foundations & Voluntary Agencies	19.48	16.83	- 2.65
Commercial	4.78	2.96	- 1.82
*Own Organization	57.76	51.16	- 6.60

* This figure is high to whatever extent authors inadvertently omit acknowledgment of grant support.

The growing contribution of National Institutes of Health grant supported research to current medical literature is quite striking. If one makes the assumption that research so supported is of equal quality, then in 1950 National Institutes of Health grants contributed directly to one fifth of the total contribution. If one eliminates articles from all sources but universities and colleges, one sees interesting trends in the sources of support. The percentage figures in Table XI are somewhat misleading in that they are relative rather than absolute. Actually, the volume of publications increased substantially from 1948 to 1951 so that the real change represents a rapid growth by National Institutes of Health supported research while that supported by other agencies increased less rapidly. This is in accord with Deignan's[1/] findings which show increased financial support from almost all granting agencies.

TABLE XI.

Acknowledged Financial Support of Medical Publications
Originating in Universities and Colleges

Source	1948	1951	Change
National Institutes of Health	12.60%	24.93%	+12.33%
Other Federal Agencies	10.55	9.82	- .73
Foundations & Voluntary Agencies	24.75	21.31	- 3.44
Commercial	6.72	3.97	- 2.75
Other	.72	1.65	+ .93
No Acknowledgment	44.66	38.32	- 6.34

1/ The Support of Research in Medical and Allied Fields for the Period 1946 through 1951. Stella Leche Deignan and Esther Miller, Science, Vol. 115, No. 2987, March 28, 1952.

CONCLUSION

When one considers that Public Health Service grants constituted approximately 40% of all Government and non-Government support of research in the medical and related scientific fields in Fiscal Year 1952 (last completed year), he is tempted to assume that the Public Health Service program cuts the pattern for medical research grants administration of the country. Such is not the intent, however, in presenting the data of this analysis. Rather, it has been the purpose to assemble data to permit reasonably logical conclusions as to the soundness of administration of the Public Health Service research grants program alone.

Partial validation of the index of research potential of the regions and institutions of the country, through the high correlation of comparison with studies by both the Office of Defense Mobilization and the Office of Education, lends credence to the data which show a rapid growth of the research manpower pool in all parts of the country, particularly in the West.

Relating this research potential to funds requested and grants awarded demonstrates conclusively that the Public Health Service distribution of research support for the various regions of the country continues on a remarkably equitable basis. Realizing that no formula for geographic distribution is used, one may properly assume that research potential itself is the controlling factor and that the resultant concentration of a major portion of the support in approximately a dozen institutions is not only natural but desirable. It is proper then, as well as factual, that the research assistance has been provided to the institutions having scientists qualified to request and use it.

It would be presumptuous to indicate the degree of influence of Public Health Service grants on the developing research potential but quite appropriate to recall that one fifth of all published work in over fifty leading medical and scientific journals in 1951 carries acknowledgment of Public Health Service support. Also, in this connection, one may note that roughly one third of all funds provided were for salaries of professional personnel, a large but undeterminable portion of whom are receiving training or being developed into independent researchers.

As interesting as such conclusions may be, much more important is the inference of need for continued evaluation of the administration of the program. It is not enough to describe the current scientific freedom of the investigators and equity of distribution of their support. It is incumbent, rather, that while jealously retaining the policy and practice that is commendable one critically explore the means for improvement. Subsequent analyses will therefore be concerned with such things as determination of fields of research requiring special attention and emphases, strengthening of security and stability of the investigators as a corollary to increasing of research potential, and bolstering of existing rules and policy to insure opportunity for any good scientist to work in the research area in which he has a natural interest.

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Background Information on

THE DIVISION OF RESEARCH GRANTS

History

During World War II, many medical problems of the greatest urgency had to be solved. To get answers as quickly as possible, the Federal government undertook in 1941 an emergency program of research under the aegis of the Committee on Medical Research, Office of Scientific Research and Development. Results were spectacular, raising the record of military medicine to an unparalleled high and contributing new techniques, drugs, and treatments equally useful for civilian application. The value of this research had been so clearly demonstrated by the end of the war, it became unthinkable that incompleted projects should be abandoned simply because military victory had been achieved. In late 1945, it was determined that the Public Health Service should accept responsibility for continuing some 50 of the wartime research projects into peacetime.

The Public Health Service had already accumulated experience in sponsoring medical research through grants. The first Federal program of grants-in- aid for research in the medical sciences had been inititated by the Service in 1937. This was done under provisions of the National Cancer Act, which authorized grants to institutions and individual scientists for investigations into the complex problems of cancer. At the height of the war, the Service had also been given broad authority by the Congress to make research grants in other fields: the Public Health Service Act of 1944 empowered the Surgeon General of the Service to "render assistance to appropriate public authorities, scientific institutions, and scientists

for research relating to the causes, diagnosis, treatment, control and prevention of physical and mental diseases and impairments of man." Under this authority, the present research grants program of the Public Health Service was launched, combining the inheritance of the unfinished wartime projects with its own growing research responsibilities.

The Division of Research Grants was established in January 1946 as an integral part of the National Institutes of Health--the principal research branch of the Public Health Service, located at Bethesda, Maryland.

Purpose

The underlying objective of the research grants program is to discover and develop new ways of preventing and curing illness and of prolonging the useful years of life. Research offers the main hope of finding practical answers to heart disease, cancer, arthritis, tuberculosis, schizophrenia, diabetes, epilepsy, nephritis, cerebral palsy, pernicious anemia, the common cold, and other widespread ailments. By providing financial support, the grants program makes it possible for workers in these fields to increase and intensify health-promoting and life-saving research.

The research grants program has four goals: 1) to expand research activities in universities and other institutions, 2) to stimulate the initiation of research in small colleges where previous research programs have been limited or non-existent, 3) to encourage investigators to undertake research in neglected areas, and 4) to provide training for scientific personnel.

The program of research grants actively encourages scientific investigation of specific medical problems in which scientists agree that urgently needed information is lacking. Because funds for medical studies have

been limited in the past, much important research has gone undone. Few Universities or other institutions have had sufficient money of their own to carry on the research of which they are capable. Through Public Health Service research grants, these potentialities are being realized. The program is one which provides purely additional support, however. It is designed to support research for which institutional funds are not adequate or which could not otherwise be conducted. It does not take the place of support from foundations, private philanthropy, or private health organizations.

The basic principle of freedom of the scientist is fully recognized by the research grants program. In order to achieve the greatest possible contribution to medical knowledge through research, it is considered essential not only to provide financial support, but to allow maximum freedom to scientists in utilizing their talents and abilities in exploring the unknown. Accordingly, proposals for research to be supported by grants originate with the applicant. In his proposal, plans are presented describing the work to be conducted. In carrying out his research after the grant is made, however, a grantee is free to follow whatever leads his investigation may turn up within the broadest interpretation of his project. The granting of funds does not entail in any way any degree of Federal control, supervision, or direction of the research project.

Administration

The National Institutes of Health is composed of seven research research programs: the National Cancer Institute, the National Heart Institute, the National Institute of Arthritis and Metabolic Diseases, the National Institute of Dental Research, the National Institute of Mental Health, the National Institute of Neurological Diseases and Blindness, the National Microbiological Institute, the Clinical Center

and the Division of Research Grants. Each of the seven Institutes has a program of grants and fellowships within the particular field of interest indicated by its name. In addition to the Institutes, the National Institutes of Health has two other major organizational entities: the Clinical Center, a patient research facility used by the Institutes for integrated clinical and laboratory research,, and the Division of Research Grants, which as part of its function, operates for the National Institutes of Health a unitary grants and fellowships program, similar to those of the categorical Institutes, covering those medical fields which do not fall with the scope of any one of the separate Institutes. Thus, through these programs, funds are available for supporting research in all areas related to health.

The Division of Research Grants, in addition to operating the unitary program mentioned above, serves all of the individual Institutes in administration of their grants and fellowships programs and is responsible for coordination of the Institute programs through a close-operating relationship. The Division receives all applications, assigns them to the appropriate Institute for consideration, provides technical review, and is responsible for fiscal administration of all grants programs. Since 1947, the Division of Research Grants has also been responsible for the fellowships program, under which fellowships are awarded to further the development of competent research workers in the medical sciences and related fields.

Two types of advisory and consultative groups play important roles in operation of the research grants program. Because of the breadth and complexity of medical research fields 20 panels of technical experts called Study Sections have been set up to review all research project applications. These are dynamic groups with rotating members made up of

the nation's outstanding scientists. They consist of approximately 200 specialists representing the many disciplines involved in modern medical science. A Study Section screens each grant application to ascertain the qualifications and competency of the investigators, the adequacy of the research design, the significance of the proposed study, and its relative importance in the particular area of research. Applications are rated according to merit and recommendations of the Study Sections are submitted to the second of the advisory groups--the National Advisory Councils.

Before any application for a research grant can be approved, it must be recommended by a National Advisory Council. There are seven such Councils, established by statute and composed of leaders in the medical sciences, in education, and in public affairs. These are the National AdvisoryCancer Council, National Advisory Mental Health Council, National Advisory Heart Council, National Advisory Dental Research Council, National Advisory Arthritis and Metabolic Diseases Council, National Advisory Neurological Diseases and Blindness Council, and National Advisory Health Council. One of these Councils reviews each application together with Study Section recommendation concerning it, and then formulates its own recommendation. Applications are then forwarded with recommendations to the Surgeon General of the Public Health Service, who subjects them to final review. If approved, funds are granted for carrying out the proposed research.

This critical system of review of applications assures an objective and qualified evaluation of proposed research. The outstanding scientists and laymen who participate in the consultative and advisory groups contribute a variety of skills and viewpoints which form a sound basis for selection of research to be supported.

Accomplishments

In the eight years since the Division of Research Grants was established, more than 14,000 applications have been received covering every major area of scientific research related to health. More than 7,000 grants have been made, amounting to over $100,000,000 in research support to thousands of scientists in approximately 400 research institutions, located in every State in the Nation.

The growth of research interest has been remarkable and reflects the phenomenal growth in research potential. In 1946, the first year of the broad grants program, 127 applications were received. The volume has steadily increased each year following, rising to 2,818 in 1952. The Congress has responded to the challenge and the promise held out by research for the benefit of the national health, increasing its appropriations for research grants from $780,158 in 1946 to $20,468,000 in 1953. Notwithstanding the greater funds made available for this purpose each succeeding year, there never has been enough money to pay all the applications which have been recommended by the National Advisory Councils.

The effects of the research grants program have been far-reaching although precise quantitation of the impact is difficult to gauge. It is estimated that research grants provide about 10 percent of the support from all sources of all medical research conducted in the United States. The considerable increase in recent years in the number of medical scientists in non-Federal institutions is partially attributable to the grants program. The vast increase in scientific publications is another indication of the impetus which the program has given. Medical schools, universities, and other non-profit research institutions produce approximately 65 percent of the publications in the medical sciences.

One-fourth of these publications acknowledge support under the research grants program. From such objective indications, it can be said that the program has been instrumental in greatly developing research potential, including the enlargement of research productivity in formerly neglected areas.

The contributions to medical knowledge which ultimately improve the health of our citizens are the final assessment which defines the value of a program of research support. Such an appraisal is difficult to make at any given point in time, for it takes years before many research results can be seen in their true perspective. The findings of fundamental research which are added to the storehouse of basic knowledge seldom have early application in clinical medicine, yet they are the slowly accumulated facts upon which major medical discoveries are founded. Significant achievements are always compounded of the work of many scientists, produced bit-by-bit over long periods.

The grants program supports research, both basic and applied, along the whole range of the medical and biological sciences. Since the inception of the program, however, there has been marked acceleration in research on the chronic diseases such as heart disease, cancer, arthritis, and others which are becoming more threatening to the national well-being. There has also been stimulation of research in very special fields in answer to special needs--these include studies on radiation sickness, on blood, on evaluation of ACTH and cortisone, and certain investigations related to the national defense.

Many important discoveries have been made by investigators supported, in part, by research grants. Thousands of individual findings have been obtained--all of which add to the sum of knowledge necessary to the solution of problems of disease and the promotion of health. Some examples of these advances are given below:

.....the discovery that large cholesterol-bearing molecules are present in the blood of persons with atherosclerosis, the most serious form of hardening of the arteries. This has opened up promising new leads toward understanding of the disease.

.....the first demonstration that cell particles, other than viruses which sometimes become part of a cell, have the ability to transmit cancer. The experiments indicated that cancer can be transmitted by chromatin threads or tiny fragments from malignant cells injected into previously healthy animals.

.....the development of primaquine, an effective therapeutic agent for malaria which cures the Korean type of the disease in most instances. This drug was adopted by the Department of the Army for administration to all servicemen returning from Korea.

.....the successful regeneration of nerve fibers in the spinal cord, accomplished through intravenous administration of bacterial pyrogens. This discovery in amimal experimentation gives the first real hope of developing methods of repairing spinal cord lesions such as those which result in paraplegia.

.....the development of an electronic device, called the microfluorometric scanner, which enables the user to see time pictures of the structural changes in living cells and thus promises to become a time-saving instrument for detecting cancer cells.

.....evaluation of the merits of ACTH, cortisone, and aspirin in the treatment of rheumatic fever, showing that each is effective and that the acute symptoms usually subside with use of any of the three agents.

.....the development of a new anticonvulsant drug, 5-spiro-3 ethyl-cyclopentane barbituric acid, which may prove beneficial for treatment of epilepsy. In tests on animals, it was found effective in controlling epileptic seizure and considerably less toxic than the best drug now available.

.....the devising of a plastic replacement for corneas which, tried on rabbits, grows firmly into place without damaging the eye itself and causes restoration of normal vision. This offers hope that, following more experiments with larger animals, plastic corneal grafts can be successfully implanted in human eyes for possible remedy of total and partial blindness.

.....the development and use of a mechanical heart on human patients, successfully carrying the circulation for a considerable period while the patients' own hearts were being operated on. The instrument is making possible surgery, for congenital heart defects and other heart conditions, which could not hitherto be undertaken.

.....the discovery that the causative agent of the children's disease, roseola infantum, belongs to the virus group. Roseola, which affects almost every child between the ages of 6 months and 3 years, was the last of the common rash-producing children's diseases of which the cause was unknown.

.....the development of means for replacing joints in limbs and other parts of the body where joint damage has resulted from degenerative diseases, tumors, or injuries. Progress has been made in using plastic elements in the hip, elbow, and shoulder, and is being extended to the ankle and knee.

.....the production of strains of experimental animals so closely related and uniform as to permit tumor transplantation, thus providing standardized, dependable, and inexpensive material which is used in perhaps 90 percent of cancer laboratory research.

.....the lengthening by several months of the safe storage period for red blood cells by temperature control and addition of certain chemicals. This, in effect, assists the larger stockpiling of blood for emergency use in transfusions, a vital objective in national defense.

.....the development of a method for determining when individuals exposed to industrial atmospheric contaminants, such as asbestos dust or beryllium, should be withdrawn from the environment to prevent pulmonary disability. Based on measurement of oxygen carried by blood cells, an index has been obtained of the extent to which oxygen in the blood can be reduced without damage to the worker.

.....the finding that protoveratrine, one of the veratrum alkaloids, causes marked lowering of blood pressure in certain hypertensive patients. Slow intravenous injections in patients with very high blood pressure produced, in many instances, far-reaching beneficial effects which sometimes lasted several weeks.

.....the working out of a method for diagnosing brain tumors by techniques similar to radar and sonar, whereby sound waves put through the brain can be picked up and their changed characteristics translated into a visual picture on a screen.

.....the establishment of the therapeutic effects of the antibiotics chloramphenicol and aureomycin in treatment of typhoid fever. Both drugs were beneficial in achieving good recovery of patients acutely ill, although a marked superiority of chloramphenicol was demonstrated.

.....the extension of the range of effective treatment of tuberculosis of the nervous system. A method of treatment with a combination of streptomycin and promizole has succeeded beyond expectation in delaying the spread of the disease through the body long enough for the body's defenses to develop and for most victims to survive.

.....the development of a plastic button and its successful use in repairing septal defects, or holes in the partition which separates the two sides of the heart. The hole is closed over by clamping the heart wall between the two halves of the button, which have serrated edges.

.....the clinical study of aminopterin and other antifolic acid compounds to treat the acute leukemia which accounts for a large proportion of cancer in children. Significant but temporary remissions were obtained in two-thirds of the children treated, a finding of importance since conventional therapy has little effect on this fatal disease.

.....the working out of new rules to make more exact and comprehensive the thematic apperception test, which is commonly used to gain better understanding of patients with emotional or mental disorders and which has proved an effective device for both diagnosis and prognosis. A more effective method of utilizing group Rorshach tests was also developed.

.....the remedial treatment by use of artery grafts of certain congenital heart defects and injuries resulting in blood vessel damage. It is now possible to graft pieces of artery of considerable length.

.....the development of the rice diet for the treatment of high blood pressure, which has often brought about marked and sometimes dramatic improvement in patients. Other studies have been concerned with modifying the diet so that it will be less monotonous and more palatable to patients.

.....the origination of a new type of flame photometer based on the principle that various substances when burned produce flames with measurable differences. Use of the instrument enables analysis of several hundred specimens of body fluids in a day, with greater accuracy than hitherto attainable. It has revealed that injuries may result in previously unrecognized indications of impending shock, and thus may find application to medical problems of mass disasters.

.....the development of a cure for granuloma inguinale, an incapacitating venereal disease prevalent in the Southeastern States. With study of various drugs, it was found that use of chloromycetin would effect a cure in 5 days.

.....the discovery that certain enzymes produced by disease micro-organisms can be used to break up pus formation in the body, such as occurs in tuberculosis, pneumonia, deep wounds and burns, and other infections. These enzymes, streptokinase and streptodornase, when injected into the patient, cause solid masses of pus to liquefy so that it can be easily drawn off by suction.

.....the finding that the cause of sickle cell anemia, an inherited disease found in a large percentage of negroes, is an actual difference in the chemical structure and molecular composition of the hemoglobin of such patients. This has opened the way for study of similar chemical differences which may be present in other forms of anemia.

.....the development of a dry nutritional mixture which can be mixed with water or milk and fed by tube to cancer and other patients unable to take adequate food by mouth. This dietary treatment, which can also be injected directly into the stomach without causing either vomiting or diarrhea, frequently improves nutritional status to the point where surgery becomes possible and has allowed some bedfast terminal patients to improve sufficiently to be ambulatory.

.....the clinical study of the drug hexamethonium as a blood-pressure-reducing agent. It was found that the drug reduces arterial pressure in patients with many forms of hypertension, including critical malignant types. It must be very carefully administered, however, since it may produce a number of side effects.

.....analytical findings explaining why some infants, whose blood differed from that of their mothers, died despite transfusions with their own Rh type of blood. It was found that deaths were greater when blood of male donors was used, leading to the deduction that female blood contains a protective factor. As a result, all hospitals in the U.S. now transfuse such babies only with female blood, which has further reduced infant mortality.

.....increased knowledge of factors involved in psychosomatic illness, including evidence of correlation between personality structure and arthritis, of effect of emotional tension on the severity of diabetes, and the influence of psychological factors in colitis, skin diseases, and amenorrhea.

.....the use of the metal strontium for successful treatment of osteoporosis, brittle bone disease of the aged. It was found that after maximum calcium storage in the bones, equal or greater amounts of strontium could be stored, thus aiding in remineralization.

.....the development and successful use of a plastic valve to prevent the backflow of blood into the heart caused by an impaired aortic valve. The valve contains a small plastic ball which moves to one end to allow blood to flow through and is pulled to the other end when the heart relaxes, thus preventing the blood from flowing back.

.....the finding that fluorescein, a fluorescent dye, is absorbed by all body tissues but is eliminated faster by normal tissues. This is a valuable aid to cancer diagnosis and to more accurate surgery for brain tumors, because when the dye is tagged with radioactive iodine and injected, the surgeon can survey the surface of the skull and the brain with a Geiger counter to locate the tumor.

.....the working out of safer cortisone dosage schedules for patients with arthritis and other diseases. As a result many patients can be treated without harmful side effects of the drug, such as facial changes, hirsutism, elevated blood sugar, and skin pigmentation.

.....the evaluation of the effects of the anticoagulant Dicumarol and improvement of techniques for its safe use to prevent the growth of existing blood clots and the formation of new clots in treatment of coronary heart disease. Simultaneous studies in a number of institutions rapidly obtained clinical knowledge of this life-saving drug.

.....the testing of the drug Banthine in treatment of peptic ulcer, the so-called occupational disease of the twentieth century. The drug promptly relieves ulcer pain by "blocking" the vagus nerve and thus reducing stomach acids.

.....origination of a new technique for repair of mitral insufficiency, the leaky valve condition that often occurs in rheumatic heart disease. In this method a piece of the pericardium, the sac enclosing the heart, is pulled through the heart and attached so that it will loosely move against the damaged mitral valve.

.....the development of tests for determining an individual's nutritional status with regard to the anti-pellagra and anti-beriberi vitamins, by measuring urinary excretion of the vitamins niacine and thiamine administered orally. A problem in treating malnutrition has been the difficulty of determining the specific dietary deficiencies of patients.

.....the evaluation and testing of new chemical agents for control of cancer, such as triethylene phosphoramide and 6-mercaptopurine. Although these do not produce cures, they are often effective when the patient no longer responds to treatment by x-ray, nitrogen mustards, anti-folic compounds, or hormones like ACTH and cortisone.

.....the development of the drug hydrazinophthalazine for the treatment of patients with certain types of high blood pressure. Further studies have resulted in the finding that use of this drug in combination with hexamethonium provides more effective therapy than other commonly used agents.

.....the finding that the severe crushing pain which accompanies a coronary heart attack may be diminished and in many cases eliminated by application of an ethyl chloride spray. This "freezes" the pain centers and stops the spasms, thus allowing the patient to conserve strength for the healing period.

.....new knowledge concerning the effect of steroid hormones produced by the adrenal and sex glands and their relation to various types of cancer. One of these studies showed that stilbesterol--a synthetic substance related to the normal female sex hormones--has a pronounced beneficial effect on breast cancer in women over 70.

.....the development of an artificial kidney which can temporarily take over the function of the human kidney where its function has been impaired. The artificial kidney has been successfully used on hundreds of patients, and has proved particularly valuable in treatment of anuria and post-operative shock.

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N A T I O N A L   I N S T I T U T E S   O F   H E A L T H

THE PRINCIPAL RESEARCH BRANCH OF THE PUBLIC HEALTH SERVICE

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September 1949, Bethesda, Md.

NATIONAL INSTITUTES OF HEALTH

The National Institutes of Health constitute the principal research branch of the U. S. Public Health Service. They are six in number -- the Experimental Biology and Medicine Institute, the Microbiological Institute, the National Cancer Institute, the National Heart Institute, the National Institute of Dental Research, and the National Institute of Mental Health.

The scope of their program, which is carried forward by a large complement of scientists at the Institutes' research center in Bethesda, Maryland, and at widely scattered field stations and laboratories, is almost as broad as the attack of disease itself on mankind. It extends into practically all fields of medical research and all branches of public health science.

Intramural Program

Some of the studies undertaken are fundamental; others have immediate and direct application. They may seek the nature and cause of specific diseases or pursue the development of drugs, serums, antibiotics, vaccines, or unknown agents that will aid in prevention, control, or cure. Or they may be concerned with general problems of nutrition, aviation medicine, or some other field. The studies range from a search for the causes of the common cold to the causes of cancer, from investigations of the clinical value of recently developed drugs to studies of new applications of nuclear energy.

The Institutes are frequently presented with perplexing medical and scientific problems from every section of the country and even from foreign lands. For instance, State and local health departments often call upon the Public Health Service for assistance in identifying and controlling contagious diseases and in solving other health problems.

Grants and Fellowships

The vast intramural research program is supplemented by a program of research grants and fellowships. Through the grants, hundreds of universities, hospitals, laboratories, and individual scientists receive funds to carry on special projects; through the fellowhips, promising young scientists are trained for future service. Recommendations for research grants are made by the national advisory councils of the various Institutes, and both programs are administered by a Division of Research Grants and Fellowships. Since the inception of these programs, 4,126 grants totaling $62,818,569 have been made and 1,146 fellowships awarded.

While most of the fellowships are awarded to medical students or young doctors, a few special fellowships are awarded to scientists who have already demonstrated outstanding ability or who possess specialized training for a specific problem. During the past year, for example, three Nobel Prize winners have been working at the Institutes as special fellows — Dr. Otto H. Warburg of Germany, Dr. Albert Szent-Gyorgyi of Hungary, and Dr. Bernardo A. Houssay of Argentina.

Early Days

The many well-equipped and well-staffed laboratories of the National Institutes of Health descend in direct line from a home-made microscope in a single room at the Marine Hospital on Staten Island. It was there in 1887 that Dr. Joseph J. Kinyoun built an apparatus modeled after the one used by Robert Koch, the German scientist, and demonstrated that the organism of cholera was present among passengers and crews of ships arriving in this country from the Old World. Shortly thereafter Dr. Kinyoun was sent abroad to study the new science of bacteriology under Koch in Berlin and at the Pasteur Institute in Paris.

Upon his return Dr. Kinyoun's little laboratory began to attract more and more attention, and before long it was transferred to Washington, named the Hygienic Laboratory, and given the entire top floor of a building on Capitol Hill. It was at this time that Public Health Service officers were first detailed to assist in laboratory work.

In a few years the Laboratory grew out of its Capitol Hill space, and Congress provided funds for a building on a knoll overlooking the Potomac River, not far from where the Lincoln Memorial now stands. The Laboratory remained there for almost 40 years, its one building expanding into four.

Present Facilities

In 1938 the Laboratory, by then known as the National Institute of Health, was moved to its present site on a 320-acre wooded tract in the Maryland countryside, about 12 miles northwest of Washington, D.C. The 90-acre nucleus of this tract was donated by Mr. and Mrs. Luke I. Wilson.

Emergency construction funds were allotted by the President, and six red-brick Georgian buildihgs were erected to house administration headquarters, offices, and modern laboratories. Two other permanent structures were subsequently added, one of them the Laboratory of Infectious Diseases, which is an air-sealed, air-conditioned building with special sterile rooms and cabinets with electric incinerators.

Temporary buildings have also been erected to house experimental animals and equipment and to provide space for special studies. One very large temporary structure is used for office space.

Future Facilities

Research facilities at the National Institutes of Health are to be expanded by a 14-story, 500-bed Clinical Center and associated laboratories where emphasis will be placed upon the degenerative and mental diseases, now the dominant causes of disability and death in this country.

Extensive excavation work for the Clinical Center started during the summer of 1948, and by September 1949 the substructure was nearing completion and the contract for construction of the superstructure had been awarded.

This building, scheduled for completion by July 1952, will combine within a single structure both hospital and laboratory facilities, including the usual features of a 500-bed general hospital together with medical and psychiatric social service, physical and occupational therapy, and rehabilitatioh services.

Ground was also broken during 1948 for a Radioactive Laboratory, which was practically completed by September 1949.

This building will contain laboratory units designed particularly for work with radioactive substances. Special protective features will include concrete walls two feet thick, lead-shielded hoods over the benches, and provision for the capture and safe disposal of "hot" particles from the air as well as liquid wastes.

Personnel

At the present time 2,732 people staff the laboratories, field stations, and administrative and maintenance offices of the Institutes; and of this number, 1,732 are located in Bethesda. Included in the overall figure are 239 commissioned officers of the Public Health Service and more than 514 other professional and scientific personnel. Among them are some of the outstanding scientists in their fields.

The Director of the National Institutes of Health is Dr. R. E. Dyer, who has been closely associated with the research work of the Institutes for many years.

Expansion of Program

The physical expansion of the research facilities and program of the National Institutes of Health down through the years reflects the growing demand of the public for wider participation by government in preventive medicine and medical research. As originally provided by Congress, the purpose of the Hygienic Laboratory was to investigate "infectious and contagious diseases, and matters pertaining to public health." In 1912, research functions were further defined to include "all diseases of mankind and conditions producing diseases." And in 1930 Congress established the National Institute of Health to coordinate research, and again expanded research frontiers and funds.

The first of the separate Institutes was created by Congress in 1937 -- The National Cancer Institute. The National Heart Institute and the National Institute of Dental Research are the result of legislation enacted in 1948 to increase the limited programs underway in both fields. Two other institutes, the Microbiological Institute and the Experimental Biology and Medicine Institute, resulted from an administrative reorganization of long-established laboratories; and, finally, the National Institute of Mental Health, which had been authorized by the 79th Congress, was established in April 1949.

Experimental Biology and Medicine Institute

The field of research of the Experimental Biology and Medicine Institute is that of the basic medical sciences. The objective of its studies is to advance knowledge in the prevention, cause, diagnosis, and treatment of disease in general. With a wide range of fields for study, the work of this institute is directed toward an explanation of some of the more pressing problems of universal interest in the medical world.

Here are a few examples of the projects and accomplishments of this institute during the past year:

A new antibiotic was discovered that may prove more effective than streptomycin in the treatment of tuberculosis.

A new method of estimating histamine was developed that may prove a useful tool in learning the cause and effective treatment of allergies.

Electron-microscope pictures were taken that showed for the first time the internal structure of a molecule. It was also demonstrated by electron microscopy what happens inside the cell of a bacterium when it is attacked by viruses.

A six-year study was completed which showed ultraviolet irradiation had no effect on the incidence of air-borne diseases.

Evaluation was made of the clinical effectiveness of the new analgesic drugs -- metapon, amidone, and demerol.

Microbiological Institute

The Microbiological Institute is conducting fundamental research on the relationship between disease-producing agents and the cells of their host organisms, and on conditions influencing survival of these agents. It is the oldest of the institutes in terms of program. The success of early workers in their efforts to control epidemics and plagues in this country are counted among the more spectacular achievements of the Public Health Service.

Important projects during the past year included:

1. Removal of the paralytic factor from rabies vaccine.

2. Chemical identification of one of the viruses concerned in production of the common cold.

3. The role of milk in the epidemiology of Q fever.

4. Experimental infection of rabbits with *Amoeba histolytica*.

5. Experimental transmission of human schistosomes by two species of native United States snails.

6. Proof of the importance of flies in the epidemiology of diarrhea and dysentery.

7. The epidemiology of conjunctivitis due to Koch-Weeks bacillus.

National Cancer Institute

The cause and cure of cancer are among the most urgent problems in medical research today. Cancer is the second cause of death in the country. The National Cancer Institute is making a three-pronged attack on this problem through research, control, and research grants.

Projects and accomplishments during the past year:

In testing 900 chemical compounds, 50 were found that produced destructive effects on tumors in mice, thus proving the value of a screening method in developing chemotherapeutic agents against cancer.

Hormone-induced tissue growth in the reproductive system was found to be greatly reduced in animals fed on a diet deficient in folic acid, a vitamin of the B complex. Acting on this observation, researchers used anti-vitamins to block quantitatively the growth stimulating effect of female sex hormones on the uterus.

Some new enzyme systems, discovered by investigators, were shown to be extremely low and others extremely high in tumors as compared with normal tissue.

National Heart Institute

Cardiovascular diseases are the Nation's leading cause of death and one of its major causes of disability. The National Heart Institute was established to conduct a research and training problem on a scale commensurate with the gravity of the problem.

The cardiovascular research program of the National Heart Institute includes investigations in the related field of gerontology. It was concerned during the past year with studies of exercise and work capacity, cardiovascular and metabolism research, kidney function and cardiorenal studies, the investigation of perceptual and learning ability, and also the technical development of scientific instruments (such as the electrokymograph) and methods for the diagnosis of heart diseases.

The program includes cooperative arrangements with outside institutions. It is anticipated that considerable expansion of intramural research will be made possible with the opening of the Clinical Center.

National Institute of Dental Research

The National Institute of Dental Research is seeking new and improved techniques for preventing and treating dental caries, pyorrhea, and other dental illnesses.

During the past year, fundamental scientific studies included the morphology, growth characteristics, and metabolism of oral microorganisms suspected of causing dental diseases; the physical and chemical stability of tooth substances as influenced by fluorides, citrates, and the aging processes; and the fluoridation of the Grand Rapids, Mich., public water supply.

The relative importance of polysaccharides, disaccharides, and monosaccharides in the production of dental caries was investigated.

Studies of spirochetes with the electron microscope indicated that the previously held opinion that they are devoid of flagella is incorrect.

National Institute of Mental Health

A million patients a year are treated in mental institutions in this country; and many more millions -- the estimates range from 30 to 50 million -- are handicapped by mental and emotional disorders that manifest themselves in physical complaints, anti-social behavior, and other symptoms not usually treated in mental institutions.

To combat this very serious problem, the National Institute of Mental Health fosters research programs, the training of mental health personnel, and the development of services for the prevention and early treatment of mental illness.

When the Clinical Center is completed, this institute will be able to develop a more extensive research program.

Research projects and accomplishments during the past year:

Basic knowledge was disclosed in studies of the brain which paves the way for discovery of the mechanisms and causes of epilepsy and other convulsive disorders.

Similarity between chronic barbiturate and chronic alcoholic intoxication was indicated by studies in a Public Health Service hospital for drug addicts.

Past Accomplishments

No attempt has ever been made to compile a list of the contributions to medical knowledge made by the scientists of the National Institutes of Health. The story of their work down through the years is scattered through thousands of reports in medical and scientific journals. The following list of research accomplishments indicates just a few of the many:

They developed a vaccine for typhus fever.

They developed an effective vaccine against Rocky Mountain spotted fever -- the first vaccine against any rickettsial disease.

They demonstrated that fluorides in drinking water are related to dental decay.

They did pioneer work on bacterial content of milk and prevention of milk-borne diseases, which resulted in uniform milk codes and regulations.

They developed an anti-malarial drug which, taken as a tablet once a week, promises to become a potent preventive measure.

They developed metapon, a powerful pain-killing drug which can be given by mouth and has few side reactions.

They improved yellow fever vaccine.

They discovered and described hookworm disease in this country for the first time.

They developed a vaccine against typhus fever that was used with success among servicemen during the last war.

They developed a shadowing technique in conjunction with the electron microscope that is now widely used throughout the world. This technique has made possible the visualization of many of the viruses and their study.

The list of research accomplishments could be extended over many pages, and it is never static. New accomplishments are continually being added to it through the patient work of the research scientists of the National Institutes of Health.

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