Chapter 2

# Biomedical Research and Development

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## INTRODUCTION

Even in this era of increasing disagreement over the allocation of shrinking resources, there is general agreement that a healthy population is the overall goal of efforts in the health sphere. These efforts include a range of activities, from biomedical or health-related research* through the development, application, production, delivery and use of medical technologies. The efforts in these areas are undertaken by the public sector (including Federal, State, and local governments) as well as by the private sector (including nonprofit organizations, universities, industries, and individuals).

Federal participation in the attempts to assure a healthy population have been increasing. Total national health expenditures in 1965 were $42.0 billion; the public share** was $11.0 billion, or 26.1 percent. In 1979, total national health expenditures were $247 billion, with the public share at 42.2 percent (31). Likewise, Federal support for health research and development (R&D) has been increasing, from $1.67 billion in 1970 to $4.93 billion in 1981*** (49). One of the clearest of the Federal responsibilities in health has been to support biomedical research (114).

Health-related research has been defined by the National Institutes of Health (NIH) as follows:

> Health-related research involves systematic study directed toward the development and use of scientific knowledge in the following areas:
>
> (1) The causes, diagnosis, treatment, control, prevention of and rehabilitation relating to the physical and mental diseases and other crippling impairments of mankind;
>
> (2) The origin, nature and solution of health problems not identifiable in terms of disease entities;
>
> (3) Broad fields of science important to or underlying disease and health problems; and
>
> (4) Research in nutritional problems impairing, contributing to, or-otherwise affecting optimum health. (114).

The concepts were recently summarized eloquently by Handler who wrote:

> It is no longer known who first used the term “biomedical science"—perhaps an early clinical investigator desiring to cloak his relatively crude arts with the mantle of precise science, or maybe a fundamental biologist seeking to attract funds more readily available for distinctly medical research. Be that as it may, this is a testimonial to the vitality and enormous utility of “biomedical science”--a spectrum of research extending from the most esoteric explorations of the diverse manifestations of life to astute observations made at the bedside, (30).

The Federal Government supports a range of health-related R&D activities. The basic objective of all of these activities is the production of knowledge (89,114). This knowledge may be in the form of information on health itself, on diseases and disabling conditions, or on environmental influences which impinge on health. Knowledge, in turn, results in new tools and technologies to intervene in the disease process, or to counteract the effects of disease. Some research evaluates the products of previous research while other research investigates the use of technology and other aspects of the health care delivery systems. Perhaps most important, though, is the fact that much of the existing research serves multiple purposes, and some yields results that are more valuable to solve problems in fields other than the field in which the research originated (89).

Health-related R&D have given the health care system and this country much beneficial in-

*In this paper, biomedical and health-related research are used synonymously.

**Of the public share, the Federal share has always been the largest. For example, in 1980, of total public expenditures for personal health care of $77.3 billion, $55.3 billion (71 .s percent) was Federal and $22.1 billion (28.5 percent) was State and local (31).

.* ‘Estimated.

formation and many effective technologies, but they are activities necessarily full of uncertainties. These activities may also be expensive—close to $5 billion was spent on health-related R&D in 1981 by the Federal Government alone (49). At the outset, the expenditure of Federal funds for R&D is clearly an investment in the future. Much of this investment represents a potential benefit to all of society and not just to specific individuals or groups. Thus, although a rationale and a precedent for Federal involvement in biomedical R&D exist, it is important that those moneys be spent as wisely as possible and in accord with a balance between public and scientific priorities (89,114).

# THE FORM AND RESULTS OF R&D

Ultimately, the desired result of health-related R&D is a healthier population, However, there are a number of diverse activities and intermediate results which occur after a new discovery but before a change in health status is seen. The range of activities is often broken down into loosely defined categories:

1. basic research,
2. applied research,
3. targeted development of technologies,
4. evaluation of technologies, and
5. diffusion and use of technologies.

In general, the first three categories of activities are forms of R&D which result in medical technologies. Medical technologies, then, may be termed the intermediate result of R&D. The last two categories are the utilization of the intermediate results in the refinement and application of those technologies. *

The demarcations between the categories are not clearly defined. Nevertheless, the classifications play an important role in the process of setting health care research priorities, allocating and distributing funds, and evaluating the outcomes or products of R&D efforts. The intended purpose of any given research effort is important at several levels in the health care decisionmaking and policy process. There is constant tension in the decisionmaking process between those who advocate increased funds for basic research, those who feel more work is needed in applying more fully the knowledge and technologies that exist, and those who believe that it is most important to examine what is already in place to determine how it is working and how to make it work better. An important result of these different perceived research needs is that the "label" that is affixed to a given health care program or initiative can be quite important to its ultimate success (89).

● Another form of research is research on the process involved in performing all of these activities. When this research is done on the use of medical technologies, it is often referred to as health services research.

The discussion that follows describes the forms of biomedical R&D—basic research, applied research, and development of medical technologies—and defines the immediate result of these activities—medical technology. A brief description of the lifecycle of medical technologies is then included for perspective, but the activities concerned with the evaluation, diffusion and use of the technologies will not be discussed until future chapters.

## Basic Research

There are numerous definitions of basic (biomedical) research found in the literature (82,97,98,114). The National Science Foundation (NSF) states that, "In basic research the objective . . . is to gain fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind" (82). The President's Biomedical Research Panel (98) did not formulate a precise definition, but instead suggested characteristics of basic research—that it is an exploring activity, that it requires an atmosphere of uncertainty, and that it must rely heavily on the initiative of the individual investigator or group of investigators. Viewed still another way, basic research produces the fundamental science base on which to build improved technologies to prevent and treat disease (97).

There is agreement among biomedical researchers that basic research is essential to the ultimate goal of a healthier population. Comroe and Dripps cited the following examples of the value of basic research:

> When Roentgen discovered X-rays, it was not to enable a cardiologist to visualize the coronary arteries of a patient suffering from angina pectoris; he was studying a basic problem in physics to determine the electrical nature of matter.
>
> When Carl Landsteiner discovered blood groups, it was not part of a program to make blood transfusions safe; he was investigating basic problems in immunology.
>
> When Cournand and Richards passed a catheter into the heart of man, it was not to develop a new method of diagnosing heart disease; they were attempting to measure the oxygen content of mixed venous blood in the right atrium of the heart.
>
> When Shackell developed a technique of freeze drying in ***1909***, it was not to preserve plasma or its fractions; he was studying a basic problem of the water content of liver and muscles.
>
> When Clarke, collector and amateur breeder of butterflies, studied variations in the color of butterfly wings, he had no idea that it would lead to the discovery of the Rh factor in human blood.
>
> When Davies and Brink devised an electrode for measuring the partial pressure of oxygen, it was not to monitor blood-oxygen in the intensive care unit; they were carrying out basic research (16).

The principle illustrated in these examples were summarized by Handler:

> What stands out in such histories is that each new major technique or procedure enables a leap to unanticipated new understandings and insights, that each new broad biological understanding illuminates a host of pathological circumstances never even considered by the original investigators (30).

Numerous other examples of unanticipated clinical applications from basic research could be cited. In addition, there have been studies of the cost-benefit of basic research (114). For example, Fudenberg (24) estimated that in the 6-year period from 1955 to 1961, monetary savings resulting from the prevention of poliomyelitis cases were $6 million. Savings in 1975 were estimated at $2 million per year, the approximate amount of the total NIH appropriation that year.

If called upon to prove the value of its work, the basic research community can always provide examples. However, these examples can only be compiled retrospectively. Because of its nature, the future outcome of basic research is unknown and speculative.

## Applied Research

As with basic research, there are numerous definitions of applied (biomedical) research. NSF (82) states that, "In applied research the objective . . . is to gain knowledge or understanding necessary for determining the means by which a recognized and specific need may be met." Characteristics of applied research include a high degree of certainty about the outcome of the research, the use of facts in the research which are sufficiently abundant and tested so that the outcome can be predicted, a relatively fixed protocol, and carefully planned sequential work schedules (98).

The value of applied research, because its results are more closely linked to treating or preventing disease, is not an issue. Instead, attention has focused on two questions. First, what is the appropriate amount of resources to be spent on applied research in relation to those spent on basic research? Although this question has been answered by numerous researchers and policymakers, others note that it is difficult to see how fixed percentages of future budgets can be set, since ideally the need to do applied research, at a particular time in a particular area of science, depends on what knowledge is available to be applied (98). Second, how can the lag time between the discoveries of basic research and

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their application in applied research be shortened?' This lag was a striking problem around the beginning of the century, but seems to be less of one currently (114).

## Development

The distinction between development and applied research is even fuzzier than the one between basic and applied research. Indeed, there are those who do not make one at all. However, development can be defined as "systematic use of the knowledge or understanding gained from research, including design and development of prototypes and processes. It excludes quality control, routine product testing, and production" (98).

While there are many examples of Federal support for development (i. e., the artificial heart), the area is one in which the private sector, and particularly private industry, provides significant funding. This is especially true when the object of the development process is a physical technology, such as a drug or device, and there is a perceived potential for profit (88).

## Medical Technology: Definition and Classification

As noted earlier, one of the primary intermediate results of the entire biomedical R&D process is the creation of medical technology. OTA defines technology broadly—as the practical application of organized bodies of knowledge. Medical technology, then, can be defined as the drugs, devices, and medical and surgical procedures used in medical care, and the organizational and supportive systems within which such care is provided.**

Although medical technologies are of many different types and serve a variety of functions, they can be classified into sets. A useful system for classifying medical technologies distinguishes these technologies according to two dimensions —medical purpose and physical nature. Each of these dimensions—medical purpose and physical nature—can be broken down further:

> Medical purpose: 1) A *diagnostic* technology helps in determining what disease processes occur in a patient; 2) A *preventive technology* protects an individual from disease; 3) A *therapeutic or rehabilitative* technology relieves an individual from disease and its effects; 4) An *organizational* or *administrative* technology is used in management and administration to ensure that health care is delivered as effectively as possible; and 5) A *supportive* technology is used to provide patients, especially those in hospitals, with needed services (e.g., hospital beds and food services).
>
> Physical nature: 1) A *technique* is a purposive application of skills or knowledge, or both, by a health care provider to a patient; 2) A *drug* is any chemical or biological substance that may be applied to, ingested by, or injected into humans in order to prevent, treat, or diagnose disease or other medical conditions; 3) A *device* is any physical item, excluding drugs, used in medical care, and may range from a machine requiring large capital investment to a small instrument or implement; and 4) A *procedure* is a combination, often quite complex, of provider skills or abilities with drugs, devices, or both. With procedures, the predominant factor may be either the product (drug or device), the technique, or the skills of the individual provider performing the procedure.

## Medical Technology: Its Lifecycle

In order to place in perspective the role of biomedical R&D in the ultimate application of medical technologies to improve the health of individuals and to set the stage for the discussion of technology transfer, it is useful to briefly describe the lifecycle of medical technologies. * * *

The development, diffusion, and use of medical technologies is a process that has been described as including at least seven steps (85):

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*This lag does not refer to the lag between basic research and adoption of technology in clinical practice. As will be discussed further, the lag between these events has been found too long for some technologies and too short for others.

**This discussion is drawn from two previous OTA reports—*Assessing the* Efficacy *and Safety* of *Medical Technologies* (85) and Development of *Medical Technology: Opportunities for Assessment (88).* For an expanded discussion, see those reports.

** *As in the previous section, this discussion is drawn from previous OTA reports, particularly *Assessing the Efficacy and Safety of Medical Technology* and *Development* of *Medical Technology.*

1. Discovery, through research, of new knowledge, and relation of this knowledge to the existing knowledge.
2. Translation of new knowledge, through applied research, into new technology, and development of a strategy for moving the technology into the health care system.
3. Evaluation of the safety and efficacy of new technology through such means as controlled clinical trials.
4. Development and operation of demonstration and control programs to demonstrate feasibility for widespread use.
5. Diffusion of the new technology, beginning with the trials and demonstrations and continuing through a process of increasing acceptance into medical practice.
6. Education of the professional and lay communities in use of the new technology.
7. Skillful and balanced application of the new developments to the population.

This sequence is attractive, because it offers a logical, linear model for understanding the development process and categorizes activities for discussion purposes. In addition, it highlights the fact that it is usually possible to identify a medical innovation prior to widespread diffusion, and thus intervene in the process—either to assure that technologies not properly evaluated for safety and efficacy (at a minimum) are not widely disseminated for clinical use or to speed the process for proven new technologies. Thus, like other models, it represents a desirable order for its component events.

However, medical technologies, like others, in fact emerge from a process that is far less systematic and certainly less linear than implied by the model. Certain steps in the process, especially those concerned with evaluation and demonstration, have often been skipped entirely. An additional weakness of the model is the absence of an acknowledged place for epidemiologic research, Epidemiologic methods have been used in testing efficacy and safety of medical technologies, and they have led to the discovery of causes of disease. For example, epidemiological research has shown that cigarette smoking is the major cause of lung cancer, and thus, control programs for this disease are now possible even though basic research has not as yet discovered the biological mechanism by which smoking causes cancer.

Obviously, biomedical R&D is an important component of the Iifecycle of medical technologies. Other important, and overlapping, components include evaluation and technology transfer. These additional components and their interrelationships will be discussed further in chapters 3 through 5.

## Assessments and Expectations of Biomedical R&D

Assessment of the performance of biomedical R&D involves one of two kinds of review—review of the individual steps in the R&D process or review of the final results of the R&D, changes in health status. The first kind is an assessment of how well each specific project met its goals. In the case of basic research—where the goal of the study is the production of new knowledge—the measurement of attaining the goal is often the publication output. For applied R&D, production of the targeted product is the measurement of goal achievement. This kind of assessment is also conducted at the organizational level. For example, NIH has conducted studies that measure the correlation between their support effort and biomedical publication output (89).

The second kind of assessment of health-related R&D is concerned with measuring the changes in mortality and morbidity. In this area, the expectations of health research often seem unrealistic. Great cures or changes in health statistics, particularly mortality, can no longer be expected in the short run (114). From 1900 to 1975, the increase in life expectancy at birth was greater than 20 years (56). There is no doubt that medical advances in antibiotics and vaccines and the resulting control of infectious diseases are strongly related to this dramatic increase. In the current era, however, chronic diseases dominate the causes of morbidity and mortality, These diseases are not likely to lend themselves *as* easily to molecular solutions, since we do not yet understand their mechanisms. Factors difficult to control such as environment, genetics, and personal health habits play a role. And since chronic diseases generally become evident late in life, gains in life expectancy from their control are likely to be small compared to the years of life saved in children cured of an acute disease (56).

# THE ROLE OF NIH IN BIOMEDICAL RESEARCH

## The Federal Role

It is estimated that national support for health-related research in fiscal year 1981 totaled $8.47 billion. Of that amount, 58.3 percent, or $4.93 billion, came from the Federal Government. Industry expended $2.7 billion, or 32.0 percent of the total. The remainder, in decreasing order of percent of the total, was spent by State and local governments, voluntary health agencies, other private nonprofit organizations, and private nonprofit foundations (49).

As indicated in table 1, the Federal share of the national support for health R&D has generally decreased over the past decade. The Federal Government has continued to provide the majority of support since 1960, however. Industry's share of the total health R&D effort has steadily increased—in 1960, industry supported 28.6 percent of the total compared with 32.0 percent in 1981 (101). Most expenditures by industry for health-related R&D represent studies relating to drug development (114).

The national support for health R&D as a percentage of all R&D increased rapidly during the 1960's and has remained fairly constant at around 12.4 percent since 1976 (see table 2). A

**Table 1.— Federal Health R&D as a Proportion of Total U.S.-Funded Health R&D, 1960-80**[a] (dollars in millions)

| Year | Health R&D | | | Federal health R&D as a percent of total health R&D |
|---|---|---|---|---|
| | Total[b] | Federal | Non-Federal | |
| 1960 | $ 884 | $ 448 | $ 436 | 50.7 "/0 |
| 1961 | 1,085 | 574 | 511 | 52.9 |
| 1962 | 1,330 | 782 | 548 | 58.8 |
| 1963 | 1,523 | 919 | 604 | 60.3 |
| 1964 | 1,695 | 1,049 | 646 | 61.9 |
| 1965 | 1,890 | 1,174 | 716 | 62.1 |
| 1966 | 2,111 | 1,316 | 795 | 62.3 |
| 1967 | 2,345 | 1,459 | 886 | 62.2 |
| 1968 | 2,568 | 1,582 | 986 | 61.6 |
| 1969 | 2,785 | 1,674 | 1,111 | 60.9 |
| 1970 | 2,846 | 1,667 | 1,179 | 58.6 |
| 1971 | 3,167 | 1,877 | 1,290 | 59.3 |
| 1972 | 3,527 | 2,147 | 1,380 | 60.9 |
| 1973 | 3,735 | 2,225 | 1,510 | 59.6 |
| 1974 | 4,431 | 2,754 | 1,677 | 62.2 |
| 1975 | 4,688 | 2,832 | 1,856 | 60.4 |
| 1976[c] | 5,084 | 3,059 | 2,205 | 60.2 |
| 1977 | 5,594 | 3,396 | 2,198 | 60.7 |
| 1978[c] | 6,249 | 3,811 | 2,438 | 61.0 |
| 1979 | 7,097 | 4,325 | 2,772 | 60.9 |
| 1980 (est.)[c] | 7,894 | 4,726 | 3,168 | 59.9 |
| 1981 (est.) | 8,456 | 4,932 | 3,524 | 58.3 |

[a] Excludes research training and construction Includes U. S-funded health R&D support spent abroad.
[b] Revised.
[c] Beginning with fiscal year 1975, Federal health R&D data are collected biennially. For agencies other than PHS, HCFA, VA, and the Consumer Product Safety Commission, health R&D figures are estimated by NIH for intervening years.

SOURCES. 1980-80 Data, National Institutes of Health, *1981 NIH Almanac,* NIH publication no, 81-5, 1981.
1981 Data, National Institutes of Health, *Basic Data Relating to the National Institutes of Health: 1981,* May 1981.

**Table 2.—U.S. Health R&D as a Proportion of Total U.S. R&D, 1960-80[a]**
(dollars in millions)

| Year | Total U.S. R&D | U.S. health R&D | Health R&D as a percent of total R&D |
|---|---|---|---|
| 1960 | $13,523 | $ 863 | 6.4% |
| 1961 | 14,316 | 1,058 | 7.4 |
| 1962 | 15,394 | 1,289 | 8.4 |
| 1963 | 17,059 | 1,475 | 8.6 |
| 1964 | 18,854 | 1,645 | 8.7 |
| 1965 | 20,044 | 1,833 | 9.1 |
| 1966 | 21,846 | 2,050 | 9.4 |
| 1967 | 23,146 | 2,276 | 9.8 |
| 1968 | 24,604 | 2,488 | 10.1 |
| 1969 | 25,631[b] | 2,697 | 10.5 |
| 1970 | 25,910[b] | 2,765 | 10.7 |
| 1971 | 26,604[b] | 3,063 | 11.5 |
| 1972 | 28,426[b] | 3,418 | 12.0 |
| 1973 | 30,631[b] | 3,587 | 11.7 |
| 1974 | 32,768[b] | 4,236 | 12.9 |
| 1975 | 35,256[b] | 4,478 | 12.7 |
| 1976[c] | 38,960[b] | 4,848 | 12.4 |
| 1977 | 43,013b | 5,318 | 12.3 |
| 1978[c] | 48,286[b] | 5,942 | 12.3 |
| 1979 | 54,296[b] | 6,732 | 12.4 |
| 1980(est.) | 60,375 | 7,468 | 12.4 |

aExcludes research training and construction. Also excludes U.S -funded R&D Support spent abroad.
bRevised
cBeginning with fiscal year 1975, Federal health R&D data are collected biennially. For agencies other than PHS, HCFA, VA, and the Consumer Product Safety Commission, health R&D figures are estimated by NIH for Intervening years.

SOURCE. National Institutes of Health, *7981 NIH Almanac*, NIH publication no. 81-5, 1981.

similar trend for Federal health R&D expenditures as a proportion of total Federal R&D expenditures can be seen in table 3.* In contrast, the percentage of the Federal health dollar spent on R&D activities has decreased. In 1974, approximately 10 percent of the Federal health dollar supported R&D (l14), but in 1980, only 7.9 percent did.**

## Agencies Participating in Health R&D

Federal funds for health-related R&D are channeled primarily through NIH. In 1980, NIH support for health R&D accounted for 67.3 percent of the Federal support (48). However, a number of other Federal agencies participate in health R&D. Their contributions are shown in table 4.

‘The drop in 1981 may appear because the figures come from budget authority rather than actual expenditures,

* ‘The 7.9 percent figure is derived as follows: 1980 Federal persona] health expenditures were $55,3 billion (31 ). Federal health R&D expenditures were $4.726 million (49). The R&D expenditures as a percent of the sum of the two figures (representing total Federal health expenditures) is 7.9 percent.

## Growth of the NIH Program

Prior to World War II, biomedical research in the United States was a small activity, primarily academically based. During the 20-year period following World War II, the field of biomedical research experienced very rapid growth (114). This growth can be seen in table 5. The National Cancer Institute (NCI), authorized in 1973, awarded its first research grants in 1938. At that time, NIH was a separate organization conducting intramural research. The Public Health Service Act of 1944 consolidated and revised existing legislation, making NCI a division in NIH and authorizing NIH to expand its research programs through an extramural grants program. In December 1945, 44 wartime research contracts were transferred to the Public Health Service (PHS) jurisdiction, giving sufficient funds for a general extramural research program. A research grants office was created at NIH in early 1946 to administer these projects and to operate a program of research grants and fellowship awards. This office became the Division of Research Grants (DRG) later that year, and the number and amount of grants began to climb.

**Table 3.—Federal Health R&D as a Proportion of Total Federal R&D, Fiscal Years 1960-80a' b (dollars in millions)**

| Year | Total Federal R&D | Federal health R&D | Federal health R&D as a percent of total Federal R&D |
|---|---|---|---|
| 1960 | $ 7,552 | $ 448 | 5.9% |
| 1961 | 9,059 | 574 | 6.3 |
| 1962 | 10,290 | 782 | 7.6 |
| 1963 | 12,495 | 919 | 7.4 |
| 1964 | 14,225 | 1,049 | 7.4 |
| 1965 | 14,614 | 1,174 | 8.0 |
| 1966 | 15,520 | 1,316 | 8.6 |
| 1967 | 16,529 | 1,459 | 8.8 |
| 1968 | 15,921 | 1,582 | 9.9 |
| 1969 | 15,641 | 1,674 | 10.7 |
| 1970 | 15,339 | 1,667 | 10.9 |
| 1971 | 15,543 | 1,877 | 12.1 |
| 1972 | 16,496 | 2,147 | 13.0 |
| 1973 | 16,800 | 2,225 | 13.2 |
| 1974 | 17,411 | 2,754 | 15.8 |
| 1975 | 19,039 | 2,832 | 14.9 |
| 1976[c] | 20,780 | 3,059 | 14.7 |
| 1977 | 23,984 | 3,396 | 14.2 |
| 1978[c] | 26,388 | 3,811 | 14.4 |
| 1979 | 28,978 | 4,325 | 14.9 |
| 1980(est.)[c] | 31,878 | 4,726 | 14.8 |
| 1981 | 35,523 | 4,932 | 13.8 |

aExcludes research training and construction, Includes U.S.-funded health R&D support spent abroad.

bRevised.

cBeginning with fiscal year 1975, Federal health R&D data are collected biennially. For agencies other than PHS, HCFA, VA, and the Consumer Product Safety Commission, health R&D figures are estimated by NIH for intervening years

SOURCES: 1980-80 Data, National Institutes of Health, *1981 NIH Almanac,* NIH publication No. 81-5,1981.
1981 Data, National Science Foundation, "Total Federal R&D Funding Estimated To Increase 7 Percent in 1982 After September Revisions, " *Science Resources Studies: Highlights,* publication No. NSF 81-321, Dec. 15, 1981.
National Institutes of Health, Basic *Data Relating to the National Institutes of* Health: *1981,* May 1981

**Table 4.–Federal Obligations for Health R&D by Agency, 1980[a] (millions of dollars)**

| | |
|---|---|
| Department of Health and Human Services (total) | ($3,694.7) |
| National institutes of Health | 3,181.9 |
| Other Public Health Service agencies | 458.6 |
| Other DHHS agencies | 54.3 |
| Other agencies (total) | (1,028.6) |
| Department of Agriculture | 147.3 |
| Department of Defense | 211.0 |
| Department of Education | 32.1 |
| Department of Energy | 210.9 |
| Environmental Protection Agency | 78.1 |
| Agency for International Development | 13.4 |
| National Aeronautics and Space Administration | 71.8 |
| National Science Foundation | 75.7 |
| Veterans Administration | 133.4 |
| Other agencies | 54.9 |
| Total | $4,723.4 |

[a]Estimated

SOURCE: National Institutes of Health, *Basic Data Relating to the National Institutes of Health 1981,* May 1981.

The end to the rapid growth period occurred in the late 1960's, when biomedical research support faced competition with other Federal health programs, especially medicare and medicaid, and with the Vietnam War. Table 5 shows that the dollar amount of research grants dropped in 1967, rose again in 1968 and 1969, and dropped again in 1970 before climbing continuously from 1971 on. However, the rise in dollars during the **1970's** did not herald the start of a new growth period. Table *6* shows NIH obligations from *1969* through 1980 in actual and constant dollars. When inflation is taken into account, there has been fluctuation throughout the decade ending in a real drop for 1980.

## Table 5.—Number and Amount of Research Grants Awarded by the National Institutes of Health, Fiscal Years 1938-80

| Year | Number | Amount (dollars in thousands) | Year | Number | Amount (dollars in thousands) |
|---|---|---|---|---|---|
| 1938 . . . . . . . . . | 9 | $ 91 | 1960 . . . . . . . . . | 11,571 | $ 198,757 |
| 1939 . . . . . . . . . | 10 | 68 | 1961 . . . . . . . . . | 13,534 | 272,941 |
| 1940 . . . . . . . . . | 13 | 61 | 1962 . . . . . . . . . | 14,975 | 372,098 |
| 1941 . . . . . . . . . | 12 | 78 | 1963 . . . . . . . . . | 15,233 | 430,899 |
| 1942 . . . . . . . . . | 12 | 78 | 1964 . . . . . . . . . | 15,242 | 497,924 |
| 1943 . . . . . . . . . | 9 | 49 | 1965 . . . . . . . . . | 15,183 | 538,763 |
| 1944 . . . . . . . . . | 5 | 53 | 1966 . . . . . . . . . | 15,153 | 600,974 |
| 1945 . . . . . . . . . | 9 | 85 | 1967 . . . . . . . . . | 13,937 | 593,312 |
| 1946 . . . . . . . . . | 79 | 890 | 1968 . . . . . . . . . | 13,120 | 626,019 |
| 1947 . . . . . . . . . | 335 | 3,458 | 1969 . . . . . . . . . | 12,435 | 627,580 |
| 1948 . . . . . . . . . | 1,042 | 10,152 | 1970 . . . . . . . . . | 11,339 | 602,177 |
| 1949 . . . . . . . . . | 1,130 | 11,274 | 1971 . . . . . . . . . | 11,063 | 676,245 |
| 1950 . . . . . . . . . | 1,529 | 13,670 | 1972 . . . . . . . . . | 11,524 | 805,041 |
| 1951 . . . . . . . . . | 1,695 | 17,130 | 1973 . . . . . . . . . | 11,317 | 815,195 |
| 1952 . . . . . . . . . | 1,798 | 18,597 | 1974 . . . . . . . . . | 13,400 | 1,070,563 |
| 1953 . . . . . . . . . | 2,084 | 20,936 | 1975 . . . . . . . . . | 13,430 | 1,116,301 |
| 1954 . . . . . . . . . | 2,855 | 29,950 | 1976a . . . . . . . . . | 14,260 | 1,239,657 |
| 1955 . . . . . . . . . | 3,256 | 35,162 | 1977 . . . . . . . . . | 14,429 | 1,386,460 |
| 1956 . . . . . . . . . | 3,430 | 40,520 | 1978 . . . . . . . . . | 15,431 | 1,577,504 |
| 1957 . . . . . . . . . | 6,186 | 80,906 | 1979 . . . . . . . . . | 17,744 | 1,883,224 |
| 1958 . . . . . . . . . | 7,028 | 99,480 | 1980 . . . . . . . . . | 18,511 | 2,086,302 |
| 1959 . . . . . . . . . | 9,056 | 141,419 | | | |

aExcludes transition quarter.

SOURCE National Institutes of Health, 1981 NIH *Almanac, NIH* publication No 81.5,1981

## Table 6.—NIH Obiigations by NIH Component, Fiscal Years 1969-80a

(in current and constant dollars (millions~ excluding programs that have been transferred out)

| Fisc~ year | Total[b] | NIA | NIAID | NIADDK | NCI | NICHD | NIDR | NIEHS | NEI | NIGMS | NHLBI | NINCDS | DDR[c] | FIC | NLM | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Current dollars | | | | | | | | | |
| 1969 | $1,087.7 | $— | $ 92.8 | $140,3 | $182.4 | $ 71.2 | 29.6 | 17.9 | $ 21.5 | $160.1 | $161.9 | $104.6 | $ 653 | $13.1 | $21.7 | |
| 1970 | 1,057.8 | | 97.1 | 131.5 | 181.3 | 76.0 | 28.7 | 17.3 | 22.8 | 148.1 | 160,3 | 972 | 62.6 | 2.7 | 19.8 | |
| 1971 | 1,212.0 | | 102.1 | 137.9 | 232.9 | 94.7 | 35.2 | 20.1 | 30,0 | 159,8 | 194.8 | 103.4 | 662 | 3 4 | 214 | |
| 1972 | 1,505.8 | | 109.0 | 153.3 | 378.6 | 116.5 | 43.3 | 26.4 | 36.9 | 173.3 | 232.6 | 116.4 | 750 | 4 2 | 23.9 | |
| 1973 | 1,523.1 | — | 103.0 | 142.8 | 431.2 | 111.2 | 40.9 | 26.1 | 34.4 | 154.0 | 255.7 | 107,4 | 728 | 3 9 | 25.0 | |
| 1974 | 1,994.4 | | 120.8 | 177.4 | 581.0 | 144.1 | 50.0 | 32.1 | 45.2 | 188,6 | 327.3 | 1435 | 1301 | 5.0 | 29,2 | |
| 1975 | 2,106.9 | | 119.4 | 173.6 | 699.3 | 142.4 | 50.0 | 35.9 | 43.7 | 189.5 | 327.8 | 1424 | 127,1 | 5.7 | 28.8 | |
| 1976 | 2,238.4 | 19.2 | 125.6 | 174.9 | 760.5 | 135.9 | 50.7 | 36,8 | 50.1 | 1869 | 368.6 | 1404 | 1303 | 5 7 | 270 | |
| 1977 | 2,582.0 | 29.9 | 140.4 | 219.4 | 814.9 | 145.1 | 55.4 | 50.9 | 63.7 | 204.8 | 396.5 | 154.6 | 137,4 | 77 | 34.5 | |
| 1978 | 2,828.0 | 37.1 | 161.8 | 259.9 | 872.4 | 165.8 | 61.7 | 63.9 | 85.2 | 230,4 | 447.8 | 1773 | 144.8 | 8.3 | 360 | |
| 1979 | 3,184.6 | 56.5 | 191 1 | 302.7 | 936.7 | 197.3 | 65.0 | 77.5 | 104.9 | 277.3 | 510.0 | 212.1 | 1541 | 8 9 | 405 | |
| 1960 | 3,428,8 | 69.7 | 214.7 | 340.1 | 998.0 | 208.3 | 67.6 | 83.6 | 1096 | 3123 | 527.1 | 241.4 | 1691 | 8.7 | 439 | |
| | | | | | | | Constant dollars | | | | | | | | | |
| | | | | | | | | | | | | | | | | Index |
| 1969 | 1,087.7 | — | 92.6 | 140.3 | 182.4 | 71.2 | 29.6 | 17.9 | 21.5 | 160.1 | 161.9 | 104.6 | 653 | 131 | 217 | 100.0 |
| 1970 | 995.3 | — | 91.4 | 123.7 | 170.6 | 71.5 | 27.0 | 16.3 | 21.5 | 139,3 | 150.8 | 91.5 | 58.9 | 2 5 | 21.7 | 1063 |
| 1971 | 1,077.8 | — | 90.8 | 122.8 | 207.1 | 84.2 | 31.3 | 17.9 | 26.7 | 142.1 | 173.2 | 92.0 | 58.9 | 3 0 | 19.0 | 112.5 |
| 1972 | 1,275.7 | — | 92.3 | 129.9 | 320.7 | 987 | 36,7 | 22.4 | 31.3 | 146.8 | 197.1 | 98.6 | 63.5 | 3.6 | 20.2 | 118.0 |
| 1973 | 1,231.6 | | 83.3 | 115.5 | 348.7 | 89.9 | 33.1 | 21.1 | 27.8 | 124.5 | 206.8 | 86.8 | 589 | 3.2 | 20.2 | 1237 |
| 1974 | 1,516.2 | — | 91.6 | 134.9 | 441.7 | 109.5 | 38.0 | 244 | 34.4 | 143.4 | 248,9 | 109.1 | 98.9 | 3.8 | 222 | 1315 |
| 1975 | 1,446.4 | — | 82.0 | 119.2 | 480.3 | 97.8 | 34.3 | 24.7 | 30.0 | 130.2 | 225.1 | 97.8 | 87.3 | 3 9 | 198 | 1456 |
| 1976 | 1,430.5 | 12.3 | 80.3 | 111.8 | 486.0 | 86.8 | 32.4 | 23.5 | 32,0 | 119.4 | 235.6 | 89.7 | 83.3 | 3.6 | 173 | 1565 |
| 1977 | 1,528.4 | 17.7 | 83.1 | 129.9 | 482.4 | 85.9 | 32.8 | 30.1 | 37,7 | 121,2 | 234.7 | 91.5 | 813 | 4 6 | 20.4 | 1689 |
| 1978 | 1,558.0 | 20.4 | 89.1 | 143.2 | 460.6 | 91.3 | 34,0 | 35.2 | 46.9 | 126.9 | 246.7 | 97.7 | 798 | 4 6 | 19.8 | 181.5 |
| 1979 | 1,620.8 | 28.8 | 97.3 | 154.1 | 476.7 | 100.4 | 33.1 | 39.4 | 53.4 | 141.1 | 259.6 | 107,9 | 784 | 4 5 | 20.6 | 196.5 |
| 1980 | 1,599.3 | 32.5 | 1001 | 158.6 | 465.5 | 97.2 | 315 | 39.0 | 511 | 1457 | 2458 | 112.6 | 78.9 | 4.0 | 20.5 | 214.4 |

aOD buildIngs and facilities, are included in totals only. Excludes Foreign Currency Programs. Constant dollars are based On biomedical R&D Price Index
bED for 1969 and DCRT for 1969-1970, when these programs were separately budgeted, are shown in totals onlY.
concludes GRS programs for 1974-1980, formerly spread among I/RDs (but 1973 funds released in 1974 are spread)

SOURCE National Institutes of Health, *Basic Data Relating to the National Institutes of Health*. 1981, May 1981.

# ORGANIZATION OF NIH*

NIH is an agency of PHS in the Department of Health and Human Services (DHHS). Its mandate, stated broadly, is to improve human health by increasing understanding of the processes underlying health and acquiring new knowledge to prevent, detect, diagnose, and treat disease and disability.** This mission is pursued via an array of intramural programs conducted at NIH and through an extensive network of extramural grants and contracts to private and public institutions in the United States and other countries. The bulk of the actual research is done extramurally; in 1980, 16.4 percent of NIH's $3.4 billion in obligations were for direct activities including intramural research, while the remaining 83.6 percent were for extramural grants and contracts (49).

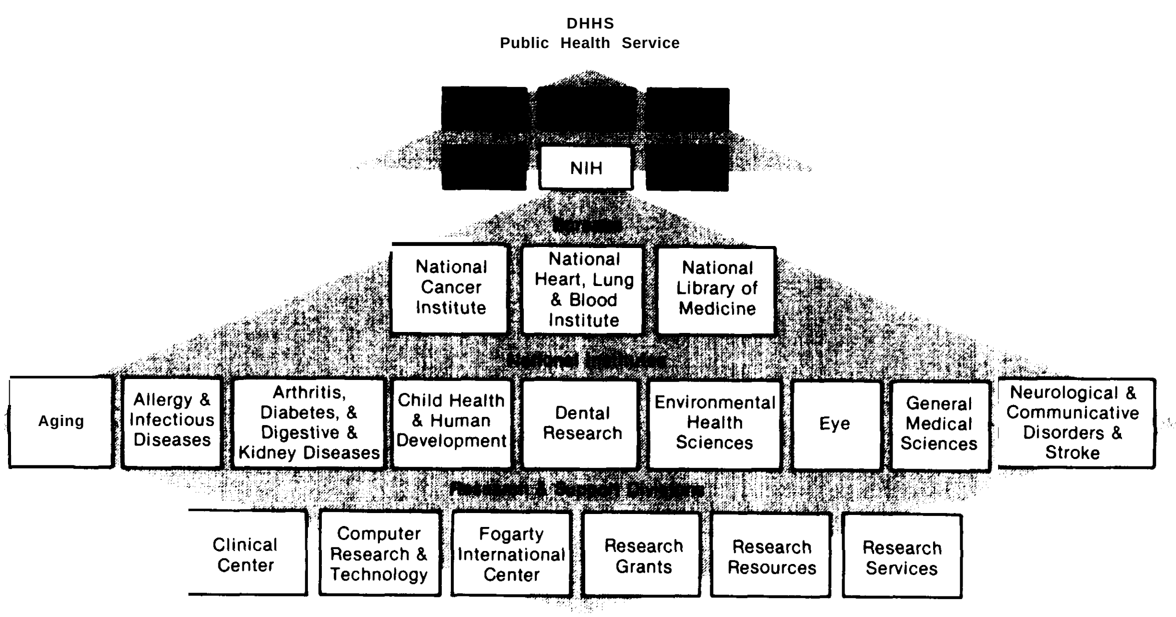
NH-I is organized into 11 institutes (two of which have bureau status), the National Library of Medicine (NLM, which is also a bureau), and six research and support divisions. Figure 1 shows the NIH components. The organization has been characterized as loosely categorical, meaning that the various research institutes focus, in a general sense, on particular classes (categories) of diseases or subject matter (7). The scientific content of two of the institutes, the National Institute of Aging and the National Institute of Child Health and Human Development, is organized around biologic processes, and thus tends to cut across the programs of the more traditional institutes. Their organization has been said to solve some, but create other, coordination problems. Overall, the categorical structure has been both praised and criticized (114).

The institutes differ in their statutory bases. Two institutes, NCI and the National Health, Lung, and Blood Institute (NHLBI), have renewable authorizations with monetary ceilings. Other institutes have authorizing statutes with no time or money limitations, One institute, the National Institute of Environmental Health Sciences, has no specific authorizing statute, but depends on section *301* of the Public Health Service Act. The institutes also differ in their re-

*This discussion is drawn primarily from *The Implications of Cost- Effectiveness Analysis of Medical Technology (89)* and *Investigation of the National Institutes of Health* (114).

**The mission will be discussed more fully in ch. 5.

**Figure 1 .—The Organization of the National Institutes of Health**




SOURCE: National Institutes of Health, *Basic Data Relating to the National Institutes of Health:1981,* May 1981.

lationship to PHS. Two institutes–NCI and NHLBI—as well as NLM, are bureaus in PHS. The remaining institutes and support divisions are division level organizations in PHS. Although the bureaus are an echelon above the divisions, the difference in these designations is largely cosmetic (107) in terms of operations. Additional differences exist among the institutes in the way that they carry out their business, in the philosophy of the staff, and in the mechanisms used to conduct research. Part of these differences are defined in statutes, and part are a result of individual institute determination.

These various semiautonomous organizations are coordinated through the Office of the Director of NIH. The Office of the Director is organized along managerial, rather than substantive, lines and reflects the principle of centralizing supporting services wherever feasible, but placing essentially all program operations within the bureau and division levels. It also reflects the role of the Director, which is primarily to coordinate program and policy development and to integrate resource procurement and execution among the institutes and divisions. There have been longstanding proposals by NIH and others to strengthen the Director's hand, such as additional staff for the Director's Office and limited authority for the transfer of funds from one appropriation to another. They continue to be rejected *(107).*

## Extramural Research Programs

As noted, the extramural research programs comprise the bulk of NIH's budget. And, as shown in table 7, research grants are the primary funding mechanism, budgeted at nearly *$2.4* billion out of a total of over *$3.6* billion for all progams and operations in fiscal year *1982.* Out of the research grants, research project grants receive the bulk of the funds. Program project grants and center grants are two additional important categories of research grants. Most of the remaining extramural dollars go to R&D contracts and to individual and institutional training awards. Technology transfer activities are funded by grant and by contract; these two mechanisms will be described in greater depth. A relatively new funding mechanism, the cooperative agreement, is being used more frequently (as mandated by the Federal Grant and Cooperative Agreement Act of 1977). Some existing grants and contracts are being converted to this mechanism. However, since there are few cooperative agreements in place, they will not be discussed further in this chapter. *

## Intramural Research

The conduct of biomedical research within the walls of NIH is the oldest of NIH's missions. Ten of the eleven institutes have intramural programs, with the National Institute of General Medical Sciences as the only exception. The role of the intramural programs in relation to the extramural programs tends to vary from institute to institute. Some activities are similar, except for their precise subject matter, to extramural activities. Others are complementary to the outside world in the sense that they are too expensive, too risky, too uncertain, or have too long a time frame. In addition, there are intramural research activities underway in areas where there is a definite national lack of research resources.

*NCI expects to fund all of its clinical trials by the cooperative agreement mechanism by 1983 (66). An NCI publication notes, "When the purpose of the relationship is the same as that of grants, but the Federal Government anticipates substantial involvement with the recipient during the course of the activity, a cooperative agreement is the funding instrument to be used. " (66) The cooperative agreements will be funded using a process similar to the process now used for grants, rather than the one used for contracts.

## Table 7.—1982 Continuing Budget Resolution for NIH by Funding Mechanism (in thousands)

| | NCI | NHLBI | NIDR | NIADDK | NINCDS | NIAID | NIGMS | NICHD | NEI | NIEHS | NIA | RR | FIC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Research grants*** | | | | | | | | | | | | | | |
| Research projects: | | | | | | | | | | | | | | |
| Noncompeting projects | $259,834 | $211,293 | $23,232 | $176,217 | $107,309 | $110,080 | $182,311 | $89,474 | $64,206 | $24,788 | $29,668 | — | — | $1,278,412 |
| Administrative supplementals | 6,727 | 1,455 | — | 1,920 | 864 | 288 | 878 | 1,369 | 650 | 35 | 146 | — | — | 14,332 |
| Competing projects: | | | | | | | | | | | | | | |
| Competing renewals | [illegible] | [illegible] | 3,078 | 24,819 | 29,923 | 22,375 | 55,454 | 19,364 | 15,594 | 5,260 | 6,497 | — | — | 272,174 |
| New | [illegible] | [illegible] | 6,841 | 37,378 | 20,465 | 19,682 | 27,256 | 19,616 | 12,328 | 5,904 | 13,739 | — | — | 247,251 |
| Supplemental | [illegible] | [illegible] | — | 960 | 325 | 633 | 1,017 | 360 | 215 | — | 78 | — | — | 8,160 |
| Subtotal, competing | 86,813 | 91,611 | 9,919 | 63,157 | 50,173 | 42,690 | 83,727 | 39,340 | 28,137 | 11,164 | 20,314 | — | — | 527,585 |
| Subtotal, research projects | 353,374 | 304,359 | 33,151 | 241,294 | 158,886 | 153,058 | 266,916 | 130,183 | 92,993 | 35,987 | 50,128 | — | — | 1,820,329 |
| Research centers: | | | | | | | | | | | | | | |
| Specialized/comprehensive centers | 72,131 | 64,808 | 8,699 | 23,401 | 21,852 | 4,600 | 12,407 | 24,589 | 4,250 | 10,052 | 61 | — | — | 246,950 |
| General clinical research centers | — | — | — | — | — | — | — | — | — | — | — | $64,324 | — | 64,324 |
| Biotechnology research centers | — | — | — | — | — | — | — | — | — | — | — | 17,712 | — | 17,712 |
| Laboratory animal sciences & primate research | — | — | — | — | — | — | — | — | — | — | — | 24,353 | — | 24,353 |
| Gorgas Memorial Institute | — | — | — | — | — | — | — | — | — | — | — | — | $1,692 | 1,692 |
| Subtotal, research centers | 72,131 | 64,808 | 8,699 | 23,401 | 21,852 | 4,600 | 12,407 | 24,589 | 4,250 | 10,052 | 161 | 106,389 | 1,692 | 355,031 |
| Other research: | | | | | | | | | | | | | | |
| Research career programs | 4,973 | 14,476 | 891 | 11,276 | 7,621 | 3,012 | 902 | 3,040 | 1,378 | 663 | 2,166 | — | 1 | 50,398 |
| Cancer task forces | 13,770 | — | — | — | — | — | — | — | — | — | — | — | 1 | 13,770 |
| Clinical education programs | 5,800 | — | — | — | — | | — | — | — | — | — | — | 1 | 5,800 |
| Cooperative clinical research | 35,500 | 4,838 | — | — | — | — | — | — | 1,673 | — | — | — | 1 | 42,011 |
| Biomedical research support | — | — | — | — | — | — | — | — | — | — | — | 49,544 | 1 | 49,544 |
| Minority biomedical support | 2,014 | 2,112 | 101 | 1,200 | 100 | 109 | — | 479 | 118 | — | 100 | 18,065 | 1 | 24,398 |
| Other research related | 5,386 | 2,178 | 324 | 1,778 | 1,639 | 762 | 1,117 | 528 | 375 | 81 | 739 | 828 | 1 | 15,735 |
| Subtotal, other research | 67,443 | 23,604 | 1,316 | 14,254 | 9,360 | 3,883 | 2,019 | 4,047 | 3,544 | 744 | 3,005 | 68,437 | — | 201,656 |
| Total, research grants | 492,948 | 392,771 | 43,166 | 278,949 | 190,098 | 161,541 | 281,342 | 158,819 | 100,787 | 46,783 | 53,294 | 174,826 | 1,692 | 2,377,016 |
| ***Training*** | | | | | | | | | | | | | | |
| Individual awards | 3,551 | 4,826 | 1,414 | 2,692 | 3,350 | 1,901 | 4,211 | 1,445 | 940 | 606 | 608 | 21 | — | 25,565 |
| Institutional awards | 19,248 | 22,948 | 2,557 | 15,257 | 4,728 | 6,248 | 41,839 | 6,957 | 2,606 | 5,646 | 1,508 | 658 | — | 130,200 |
| Total, training | 22,799 | 27,774 | 3,971 | 17,949 | 8,078 | 8,149 | 46,050 | 8,402 | 3,546 | 6,252 | 2,116 | 679 | — | 155,765 |
| Research and development contracts | 189,224 | 56,050 | 2,135 | 9,675 | 13,133 | 10,696 | 1,307 | 21,339 | 5,591 | 10,266 | 5,605 | [illegible] | — | 327,923 |
| Extramural research | 168,450 | 48,442 | 14,686 | 47,514 | 39,404 | 42,993 | 664 | 26,098 | 12,405 | 37,392 | 14,413 | [illegible] | — | 452,461 |
| Direct operations | 41,516 | 28,100 | 6,552 | 12,499 | 13,058 | 9,403 | 8,638 | 9,473 | 3,512 | 2,802 | 4,245 | *434 | 7,078 | 151,310 |
| Management fund | (47,251) | (26,293) | (4,145) | (19,129) | (15,630) | (15,636) | (3,554) | (12,629) | (6,322) | (1,718) | (1,653) | 609 | (375) | (154,944) |
| Program management | 11,857 | 6,500 | 1,473 | 1,605 | 2,130 | 3,113 | 1,861 | 2,178 | 1,533 | 2,775 | 2,230 | 336 | 435 | 39,026 |
| Disease control | 55,323 | — | | | — | — | — | — | — | — | | | | 55,323 |
| Instruction | 4,500 | — | — | — | — | — | — | — | — | — | — | — | — | 4,500 |
| Total, I/RDs | 986,617 | 559,637 | 71,983 | 368,191 | 265,901 | 235,895 | 339,862 | 226,309 | 127,374 | 106,270 | 81,903 | 184,177 | 9,205 | 3,563,324 |
| National Library of Medicine | | | | | | | | | | | | | | 44,402 |
| Office of the Director | | | | | | | | | | | | | | 22,562 |
| Buildings and facilities | | | | | | | | | | | | | | 9,898 |
| Total, NIH | | | | | | | | | | | | | | 3,640, 86 |

SOURCE: Division of Financial Management, Office of the Director, National Institutes of Health.