AHA Medical/Scientific Statement

Special Report

The Report of the American Heart Association Task Force on Strategies to Increase Federal Research Funding

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The Charge

The charge of the task force is summarized below:

1. To examine present and projected patterns of federal biomedical research funding

The task force limited its review to cardiovascular research and training and the relationship of the research community to the National Heart, Lung, and Blood Institute (NHLBI). The task force recognizes that the NHLBI is not the sole federal agency funding cardiovascular research, but it is the major one. Data from other agencies were considered only when comparisons were sought. Similarly, although the primary concern of the task force is research funding in the United States, data from other countries were also considered when appropriate.

To discern present patterns, the task force reviewed data from the National Institutes of Health (NIH) and the American Heart Association’s Office of Public Affairs. While these data clearly depict the targeting of funds for research and training for more than 10 years, they do not necessarily depict the expenditure.

Projecting future patterns was more difficult. The task force could not find a clear statement of federal research management policy for the next decade but only an outline of possible reactions to anticipated budgetary constraints. Hence, the task force used NHLBI models that incorporate a yearly 3.7% increment in the budget.

2. To evaluate options available to the American Heart Association (AHA) to maintain adequate federal support for cardiovascular research

Before considering the options available to the AHA, the task force examined whether support of research by the federal government is an expenditure of tax dollars that benefits society. The task force considered four types of benefit:

- Improved health care: The task force traced the relation between federal funding, scientific progress, and improved health care. This relation was evaluated in terms of reduction in mortality, alleviation of suffering, improved quality of life, and increased efficiency of health care delivery.
- Scientific leadership: The relation between federal funding and research progress and its importance to the worldwide scientific community as reflected by scientific publications was considered. The US scientific community was found to have played a pivotal international role in scientific discovery and leadership.
- Economic gain: The relation of scientific progress to the function of industry and its effect on economic health was considered. First, the link between NIH-sponsored research and the resultant patents that yielded potentially beneficial therapies was examined. (Although the task force recognized that patents in other fields [e.g., diagnostic] benefit health care delivery and the economy, this potentially important area was not reviewed.) Second, the task force examined the extent to which federal funding has supported the training of scientists employed by industry.
- Intellectual enrichment: Although the task force believes that all forms of intellectual enrichment are important to society, the task force did not attempt to assign it a specific value.

Having considered the four types of benefits, the task force established that society profits from fed-
eral tax dollars spent on research support. The task force then evaluated the impact of past and present policy on science, health, and the economy, and considered the options available to the AHA to maintain adequate federal research support.

3. To make recommendations to the AHA’s Board of Directors for appropriate action

Two forms of action were recommended, one involving the AHA alone and the second requiring a coordinated effort among diverse interested parties. The two actions are in no way mutually exclusive.

The Report

Patterns of Federal Research Funding

Research grants. Present patterns of NHLBI funding.* The NHLBI budget has grown from $560 million in 1982 to $1,072 million in 1990, with most growth occurring before 1986 (Table 1). From 1982 to 1987 (with the exception of 1986), the funding component of the NHLBI budget grew by more than 10% per year. Since 1987, the budget has increased less than 10% per year, and the proposed increment for 1991 is only 3.7%, which is less than the projected rate of inflation. (See Table 1 for additional data from the National Cancer Institute and the National Institute for Neurological Disorders and Stroke.)

The impact of this pattern of research support on the number of research grants funded, administrative reductions in the approved budgets of funded grants, and the magnitude of these budgetary reductions was considered.

Number of grants funded. As seen in Table 1, the NHLBI funded 765 new and competing continuation applications in 1982. The number funded peaked in 1987 with 966 awards, followed by a dramatic decrease to 698 awards in 1989 and 601 awards projected for 1990. This decline in new awards is paralleled and explained, in part, by the increased duration of the majority of noncompeting continuation applications. For example, in 1982, the NHLBI’s average award period was 3.3 years, and only 17% of NHLBI awards were funded for 5 years or more. In 1987, the average length of the grant had increased to 4.1 years, with 51% of awards funded for 5 years or more. By 1989, 56% were funded for 5 years or more. Despite the increased duration of funding and cost of research, the 33% decline in overall new and competing applications funded since 1987 and the reduction in monies delivered to funded grants, as detailed below, exemplifies a system that is, at best, attempting to maintain a status quo rather than permitting growth. It is unfortunate that this restriction is occurring at a time when new technologies continue to expand the opportunity for substantial new discoveries.

Administrative reductions in approved budgets of funded grants. Another stifling aspect of the present situation is that significant, across-the-board cuts have been levied on new and continuing grants. To appreciate the impact of these budget cuts, it is useful to consider how grants are reviewed and recommended for funding. Applications submitted by investigators (as investigator-initiated research or in response to requests for applications) include a description of the research to be performed, a budget detailing the cost of the proposed research, and a budget justification. Members of the peer review committees, who discuss, judge, and vote on priority scores for all applications, are viewed by the NHLBI and the research community as representing excellence in the areas of science to be reviewed. The quality of the proposed research and the appropriateness of the requested budgets are evaluated during the review process. Reductions are recommended in “overbudgeted” areas. Hence, the review process,

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*Data obtained from Office of Public Affairs summary of NIH funding patterns.
as originally designed, charges those individuals considered most capable of determining the quality of the proposed research and its cost with recommending approval of the proposal and budget. In recent years, this process has, by necessity, acquired a new and increasingly restrictive dimension. Budget cuts are now often based on administrative decision rather than scientific justification as the result of limited funds. This substantially undermines the ability of funded investigators to perform their approved research.

**Impact of Reductions.** To understand the magnitude and impact of administrative reductions, the task force considered the 1989–1990 fiscal year as an example (Table 2). NHLBI grants are earmarked for a yearly 4% increment in funding, which means that in 1990, a 4% budget increase was planned for all grants active in 1989. However, in 1989, funds for research grants were cut by approximately 11.5% to 13.3%, depending on the type of grant. In 1990, the NHLBI initially announced a budget reduction of 13.9% to 14.5%. However, based on adjustments during the fiscal year (see Table 2), these reductions are now estimated at 18.5%. Hence, nearly one fifth of peer-reviewed budgets judged essential to the performance of extramural research and funded by the NHLBI in 1990 will not be funded.

Principal investigators of individual grants have latitude in determining which budgetary areas are to be reduced, and reductions may not be distributed evenly across all budgetary categories. For example, because of the time and expense involved in training skilled individuals, some investigators may concentrate budgetary reductions in supplies. The result of such an attempt to maintain salaries and keep a research group intact is likely to be an even greater decrease in productivity than might be projected by the nearly 20% budget reduction, since the reduction of funds for supplies may decrease the quantities of supplies to the point that researchers may not have enough materials with which to work.

To summarize, the duration of funding has increased, but the number of new grants is not growing. The net impact of the present funding policy dictates that nearly 20% of research funded in the past and for which funding is promised will no longer be supported.

To appreciate the seriousness of this situation, it must be understood that all research approved for funding is not and never has been funded in toto. Research is assigned a numerical grade of 1 (the highest score) through 5 (the lowest score). The availability of funds determines the lowest score that can be funded. Moreover, because of differences in grading among study sections, a normalization process has been adopted to ensure uniform funding of a certain percentile of grants. At present, the level of funding hovers around the 15th percentile of approved grants. As a result, only research that is judged "outstanding" (priority score of 1.0–1.5) is guaranteed funding. Research judged "excellent" (1.5–2.0) may or may not be funded, and research classified as "good" (score of 2.0–2.5) is categorically not funded. Although the task force supports the view that outstanding research should be encouraged and funded, there is concern that biomedical research and overall progress may suffer if research deemed "excellent" or "good" is not funded. In addition, a system without room for research that is "merely" good or even excellent may ultimately strangle itself by limiting ideas and developments that form the body of knowledge from which excellence springs. Finally, while peer review committees are quite capable of distinguishing inferior from superior work, and even good from outstanding, they cannot consistently or effectively distinguish the subtleties that separate the "excellent" or the "exceptionally good" from the "good" or the "exceptionally excellent" from the "outstanding."

At present, then, we are confronted with the startling fact that only the top 18th percentile of research judged worthy can be funded, and that severe budgetary restraints are imposed on grants that are funded.

**Projections for future NHLBI funding.** The NHLBI has developed models to predict the future of research support through the 1990s. Considering budgetary constraints, the models attempt to reach an acceptable compromise between maintaining a status quo and providing an opportunity for growth. The models assume a constant number of grants and a distribution of award durations based on fiscal year 1989 and kept constant over time. The forecast is bleak: Each year, 727 new and competing continuation grants can be funded, with approximately 56% of these funded for 5 years. The number of new grants and competing continuations funded can be increased to more than 800, but only if the number funded for 5 years is decreased to about 40%. This model illustrates the futility of a situation where options for a solution are sorely lacking because the projected budget increase is limited to 3.7% per year.

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<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Noncompeting projects (%)</th>
<th>Competing projects (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>-0.3</td>
<td>-1.5</td>
</tr>
<tr>
<td>1986</td>
<td>-4.7</td>
<td>-7.8</td>
</tr>
<tr>
<td>1987</td>
<td>-1.1</td>
<td>-10.9</td>
</tr>
<tr>
<td>1988</td>
<td>-9.6</td>
<td>-14.9</td>
</tr>
<tr>
<td>1989</td>
<td>-13.3</td>
<td>-11.5</td>
</tr>
<tr>
<td>1990**</td>
<td>-14.5</td>
<td>-13.9†</td>
</tr>
<tr>
<td>1991**</td>
<td>-11.0</td>
<td>-13.9</td>
</tr>
</tbody>
</table>

*Data from National Heart, Lung, and Blood Institute.
**Estimated. †1990 estimate of reductions necessary in competing research project grants is calculated with National Institutes of Health total competing requirements model before fiscal year begins. As a result, different reductions may be necessary when applications to be funded are actually received and reviewed. For National Heart, Lung, and Blood Institute, actual reductions in fiscal year 1990 will be approximately 18.5%.
Although reducing the average grant duration will increase the total number of grants to 800, this solution merely creates an illusion rather than the reality of more research being funded. In fact, investigators will spend and even waste time in submitting renewal grant applications, and more time and money will be required for review as well. The net result cannot be construed as providing more research, but rather, a greater number of grants of less duration and, given increased administrative demands, probably less output than could be achieved with a smaller number of grants of longer duration. For example, an investigator funded for 5 years in 1990 and again in 1995 will receive two grants in the 1990s. However, if the investigator is funded every 3 years (1990, 1993, 1996, and 1999), he or she will be on record as receiving four grants throughout the 1990s. Rather than doing more research, the investigator is likely to do less, because he or she will have to spend more time preparing grant applications for submission and review.

In summary, these models predict only the illusion of growth. To attain real growth, the system must be fueled with sufficient monies to fund research that is judged excellent or good and to permit approved research to be conducted.

Training grants. To maintain excellence in biomedical research, the brightest young people must be encouraged to train in the sciences and must be given the resources to enter a career that is exciting and offers reasonable compensation and opportunity to succeed. Obviously, education and training at the primary and secondary school levels deserve high priority to attract and prepare young persons for careers in science. However, given its charge, the task force focused on federally supported training at the graduate and postdoctoral levels.

The NHLBI has a distinguished record of training investigators. The success of training is monitored in several ways, including publication in basic and clinically oriented peer-reviewed journals and subsequent success in achieving NIH funding. Of note: Scientists trained at NHLBI expense are not tracked for their success in obtaining funding by private foundations and other sources, nor is their contribution of knowledge and effort to industry acknowledged.

The National Research Council and the Institute of Medicine recently evaluated NIH support of training programs. A committee that met in 1988 and 1989 stated the following concerns:

There exists no complete inventory of the nation's training mechanisms for biomedical and behavioral science.... [For biomedical scientists] demand (job openings) has been growing relative to supply (new PhDs) since the early 1980s. Industrial growth is over twice the rate of academic employment growth.... Most new positions in biomedical science are expected to be in industry. Unless demand growth falls considerably from historical levels and/or enrollments and degree production increase dramatically,
research fellowships has declined less over the decade, although award rates are currently in the 30% to 40% range, compared with award rates exceeding 70% in the early 1980s. Similarly, progressively fewer research career development awards have been funded. Of special concern is the decline in award rates and the number of grants funded in the clinical investigator and physician-scientist categories. For example, 20 of 70 applicants in the clinician-scientist category were funded in 1989. It is alarming that in the entire nation, only 20 such individuals were supported. Although an increase of approximately 10% in dollar support for research training and career development is projected in the NHLBI’s 1990 fiscal year, the increase in funds will support increased stipend levels rather than more opportunities for training.

It is clear that continued progress in the cardiovascular sciences requires support of research training. This training must be responsive to expanding opportunities. Failure to support research training means this nation must surrender its current leadership position and import research achievement. It should also be clear that concerns about the future of research funding must be coupled with concerns about training and development of young scientists.

The trends revealed by these data are ominous and suggest a need for comprehensive strategies to develop excellence in future generations of biomedical scientists and to enhance funding levels for research training and development. A problem exists at all levels of education in the United States. For example, among developed countries, US high school students ranked in the bottom half for scientific achievement. At the college level, degrees awarded in business and management have increased, whereas the number of physical sciences degrees has plateaued and the number of biomedical sciences degrees has decreased. The number of graduate degrees awarded has even more stark implications for biomedical investigators. Figure 3 shows that while law and business and management degrees have increased, MD and PhD degrees have reached a plateau.

In part, success in education reflects effort expended by the society responsible for motivating and training its youth. Table 3 shows that in 1977, the total research and development budget in the United States was twice the budget for acquisitions and mergers. By 1988, the proportions had practically reversed, as research and development underwent a threefold increase, whereas acquisitions and mergers increased ninefold.

The number of applications to medical schools has steadily decreased as have applicants’ grade point averages. Moreover, fewer graduates are selecting careers in research, and all indications are that the number of qualified applicants is declining at an alarming rate.

Figure 4 tracks the attrition rates of scientists in the biomedical field from 1974 to 1987 and relates these data to the “refreshment rate”:

During the 1980s the biomedical field averaged 4,500 job openings annually (1,080 scientists lost from deaths and retirements, 620...lost from net mobility, and growth requirements of 2,800). Average annual biomedical PhD production during the period was only 3,840. This contrasts sharply with the 1970s when average annual job openings for all sources were 3,660, and average annual PhD production was 3,520. Clearly the supply of new biomedical PhDs has begun to fall short of the number of job openings in the late 1980s after an extended period of approximate balance.

**Figure 3.** Number and type of graduate degrees awarded between 1960 and 1985. From Healy. Reproduced with permission.

**Figure 4.** Refreshment and attrition rates of biomedical scientists from 1974 to 1987. From Biomedical and Behavioral Research Scientists: Their Training and Supply, p 34. Reproduced with permission.

<table>
<thead>
<tr>
<th>Year</th>
<th>Acquisitions and mergers (US industry) ($ billion)</th>
<th>Total research and development (federal and private) ($ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>1982</td>
<td>54</td>
<td>79</td>
</tr>
<tr>
<td>1985</td>
<td>180</td>
<td>108</td>
</tr>
<tr>
<td>1988</td>
<td>&gt;200</td>
<td>125</td>
</tr>
</tbody>
</table>

From Healy. Reproduced with permission.
If we are to remain a technologically advanced nation rather than a nation of administrators and managers, students at all educational levels must be better prepared in the sciences. Moreover, career opportunities in the sciences must be made more attractive. This does not mean that all careers must be equally rewarded financially. However, the student considering a career in the sciences must understand that a national commitment and policy exist and that individual effort and commitment will be rewarded—at least with the likelihood of career advancement. To embark on a career dependent on 5-year grant reviews and where estimated quality of research is overshadowed by unpredictable budgetary constraints that vary with the political winds is to subject oneself to unnecessary and, in fact, unconscionable risks. These risks already appear to have been detrimental to the field of scientific endeavor, which evidently appears less attractive as a way of life than it once did.

Options to Maintain Adequate Federal Cardiovascular Research Support

The task force attempted to answer several questions before evaluating options that might be available to the AHA. It was necessary to consider these questions because their answers determined the level of effort the AHA must expend. The task force focused on cardiovascular research, but other disciplines are discussed as appropriate.

1. Is there a quantifiable relation between federal research funding and scientific progress?

This question was considered by examining the relation between federal support of research and publication in scientific journals. McAllister and Narin\(^3\) reviewed the numbers of papers originating at 110 US medical schools for which data on NIH funding were available from 1973 to 1975 (see Figure 5). There was a strong linear correlation (r=0.95) between the number of papers published (dependent variable) and NIH dollars awarded (independent variable). It was assumed that any deviation from a linear relation would indicate the effect of other factors. In fact, the only institution identified as an anomaly was Harvard, where the number of papers exceeded that predicted by the linear relation. The authors assume that this reflects other major sources of support available to Harvard (including its endowment), but this has not been tested. In addition, because of the many institutions affiliated with it, Harvard is not typical. Nonetheless, these data support the existence of a relation between federal funding of research and a definable “product” (i.e., publication of scientific papers).

2. Are the results of basic research quantifiable with respect to alleviation of suffering and improved quality of life?

In 1976, Comroe and Dripps\(^4\) reported the most comprehensive study addressing this question. They asked 40 physicians to list the clinical advances most important to patient care since the early 1940s. These selections were then classified as cardiovascular or pulmonary and sent to 40–50 specialists in those areas, who were asked to rank the importance of each advance and to add additional discoveries they thought had been overlooked. The 10 top-ranked advances are listed in Table 4. Comroe and Dripps then met with 140 consultants to determine the bodies of knowledge required for each of the 10 areas of clinical advancement to occur. For those 10 advances, 137 essential bodies of knowledge were identified. Some 4,000 articles related to these areas were then considered, of which 2,500 were judged of particular importance to at least one of the 137 bodies of knowledge. Of these, 529 were considered key articles that were absolutely essential for a clinical advance. A rating system was devised to

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**Figure 5.** Number of biomedical papers originating at 110 US medical schools (vertical axis) versus total NIH funds in millions of dollars (horizontal axis). Adapted from McAllister and Narin\(^3\) with permission.

**Table 4.** Top 10 Clinical Advances in Cardiovascular and Pulmonary Medicine and Surgery in the Last 30 Years

<table>
<thead>
<tr>
<th>No.</th>
<th>Advance</th>
<th>Key Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cardiac surgery (including open heart repair of congenital defects and replacement of diseased valves)</td>
<td>529 articles</td>
</tr>
<tr>
<td>2</td>
<td>Vascular surgery (including repair or bypass of obstructions or other lesions in aorta, coronary, cerebral, renal, and limb arteries)</td>
<td>529 articles</td>
</tr>
<tr>
<td>3</td>
<td>Drug treatment of hypertension</td>
<td>529 articles</td>
</tr>
<tr>
<td>4</td>
<td>Medical treatment of coronary insufficiency (myocardial ischemia)</td>
<td>529 articles</td>
</tr>
<tr>
<td>5</td>
<td>Cardiac resuscitation, defibrillation, cardioversion, and pacing in patients with cardiac arrest, slow hearts, or serious arrhythmias</td>
<td>529 articles</td>
</tr>
<tr>
<td>6</td>
<td>Oral diuretics (in treatment of patients with congestive heart failure or hypertension)</td>
<td>529 articles</td>
</tr>
<tr>
<td>7</td>
<td>Intensive cardiovascular and respiratory care units (including those for postoperative care, coronary care, respiratory failure, and disorders of newborns)</td>
<td>529 articles</td>
</tr>
<tr>
<td>8</td>
<td>Chemotherapy and antibiotics (including prevention of acute rheumatic fever and treatment of tuberculosis, pneumonias, and cardiovascular syphilis)</td>
<td>529 articles</td>
</tr>
<tr>
<td>9</td>
<td>New diagnostic methods (for earlier and more accurate diagnosis of disease of cardiovascular and pulmonary-respiratory systems)</td>
<td>529 articles</td>
</tr>
<tr>
<td>10</td>
<td>Prevention of poliomyelitis (especially of respiratory paralysis due to polio)</td>
<td>529 articles</td>
</tr>
</tbody>
</table>

From Comroe and Dripps\(^4\) Reproduced with permission.
identify whether the goals of each of the key papers were “clinically oriented” or “not clinically oriented” research. It should be understood that the two categories do not indicate whether the research was “basic.” In fact, research in both categories could be basic; however, research in the latter had no clinical goal whatsoever. Table 5 incorporates the results of this analysis, which indicates that a substantial percentage of the research that resulted in major clinical advances had no clinically oriented goals. Moreover, basic research, whether clinical or nonclinical in its orientation, constituted over 60% of the total papers reviewed.

Hence, as long ago as the mid-1970s, well-quantified data reflecting the impact of basic research on the most important areas of clinical discovery were available. Nonetheless, one might question the benefit of such advances. Despite the altruistic desire to improve the lot of our fellow humans, is the high cost of research justified at a time of increasing prices and cost-consciousness? Certainly, there is no easy answer addressing all forms of therapy. One approach has been to relate accomplishments in basic and clinical research to the length of hospitalization of heart attack patients. In fact, there has been a dramatic reduction in the duration of hospitalization (associated with reduced morbidity and reduced costs) after acute myocardial infarction. It is important to note that the change in duration of hospitalization has not been sudden and attributable to a unique event unrelated to advances in science (such as the advent of diagnosis-related groups). Rather, it has been gradual. Between 1977 and 1987, the average number of days in the hospital were, respectively, 10.4, 10.2, 9.6, 9.4, 9.1, 8.8, 8.5, 7.6, 7.1, 6.7, and 6.5 (data from NHLBI). Additional data on the cost of medical care and therapy are shown in Table 6. The 5-year expected total cost per case of acute myocardial infarction is estimated at $51,211.

In contrast, the expected 5-year cost for angioplasty is $26,916, and for coronary bypass surgery, $32,465. Hence, costly as they are, two therapies whose origins lie in basic research individually are less expensive than the disease left untreated.

Between 1977 and 1987, there was a decline in the coronary heart disease death rate (see Figure 6) that has, in turn, led to an 80% increase in the prevalence of coronary heart disease (Figure 7) and a corresponding 150% increase in morbidity costs (Figure 8). Although, at first glance, this increase in costs appears staggering, the actual expense for the growing number of coronary heart disease patients is far less than expected costs based on 1977 standards of health care delivery (Figure 8). The decrease in duration of hospitalization per person from 10.4 days in 1977 to 6.5 days in 1987 has contributed to the improved efficiency of health care delivery. More important, the 1-year mortality rate in patients who received early reperfusion therapy is markedly reduced.5

### Table 5. Goal of Authors of 529 Key Articles Judged Essential for Clinical Advance

<table>
<thead>
<tr>
<th>Clinical advance</th>
<th>Clinically oriented</th>
<th>Not clinically oriented</th>
<th>Total</th>
<th>Percent of total not clinically oriented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac surgery</td>
<td>53</td>
<td>35</td>
<td>88</td>
<td>39.8</td>
</tr>
<tr>
<td>Vascular surgery</td>
<td>40</td>
<td>8</td>
<td>48</td>
<td>16.7</td>
</tr>
<tr>
<td>Hypertension</td>
<td>35</td>
<td>44</td>
<td>79</td>
<td>55.7</td>
</tr>
<tr>
<td>Coronary insufficiency</td>
<td>44</td>
<td>21</td>
<td>65</td>
<td>32.3</td>
</tr>
<tr>
<td>Cardiac resuscitation</td>
<td>24</td>
<td>16</td>
<td>40</td>
<td>40.0</td>
</tr>
<tr>
<td>Oral diuretics</td>
<td>19</td>
<td>24</td>
<td>43</td>
<td>55.8</td>
</tr>
<tr>
<td>Intensive care*</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>40</td>
<td>13</td>
<td>53</td>
<td>24.5</td>
</tr>
<tr>
<td>New diagnostic methods</td>
<td>41</td>
<td>53</td>
<td>94</td>
<td>56.4</td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>16</td>
<td>3</td>
<td>19</td>
<td>15.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>312</td>
<td>217</td>
<td>529</td>
<td>41.0</td>
</tr>
</tbody>
</table>

* A key article is assigned to only one advance, even though it may have been essential to more than one. Because practically every key article in intensive care was also essential to other advances, these articles were assigned elsewhere (for example, to cardiac or vascular surgery, coronary insufficiency, resuscitation, or antibiotics). From Comroe and Dripps. Reproduced with permission.

### Table 6. Medical Costs for Coronary Heart Disease Events (5-Year Expected Total Cost Per Case)

<table>
<thead>
<tr>
<th>Coronary heart disease diagnoses</th>
<th>Average cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute myocardial infarction</td>
<td>$51,211</td>
</tr>
<tr>
<td>Angina pectoris</td>
<td>24,980</td>
</tr>
<tr>
<td>Unstable angina pectoris</td>
<td>40,581</td>
</tr>
<tr>
<td>Sudden death</td>
<td>9,078</td>
</tr>
<tr>
<td>Nonsudden death</td>
<td>19,697</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coronary heart disease procedures</th>
<th>Average cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angioplasty</td>
<td>$26,916</td>
</tr>
<tr>
<td>Coronary bypass surgery</td>
<td>32,465</td>
</tr>
</tbody>
</table>

The total yearly economic cost of coronary heart disease to the United States has been estimated. The direct medical care cost for coronary heart disease is quoted by the NIH as $15.3 billion in 1987. The total economic cost of coronary heart disease is estimated to be $54.7 billion annually. When compared with an annual NHLBI budget of slightly over $1 billion, it is obvious that a major increment in the research budget is justified to combat coronary and other forms of cardiovascular disease. Despite this perceived need, the percent of the gross national product and of the federal health care budget targeted for basic research and development has steadily diminished. For example, in 1967, nearly 3% of the health care budget was assigned to research and development, compared with only 1.6% in 1987 (data from NIH). Over the same period of time, while constant dollars for the NIH increased by 23%, defense research and development dollars increased by 112%.

3. Is the result of basic research quantifiable with respect to the economy?

To answer this question, the relation of research to patents was reviewed. As an example, the relation of prostaglandin research to the generation of patents has been quantified.6 Of 1,778 papers identified for review by the investigators, 25.3% identified the NIH as the source of research support. The National Science Foundation supported 3.1% and various foreign sources supported 10.1%. Figure 9 shows the relation between published research and the appearance of patents. As the authors noted, the number of basic papers peaked before the patents, and a temporal relation between papers and patents is readily identifiable.

Given the relation between basic research and the development of patents, what is the economic market under consideration? The worldwide pharmaceutical market is estimated to be $80 billion per year; cardiovascular drugs account for 20% of that market.7 This represents a thriving industry that has a major impact on the national health, both medical and economic.

Any threat to the basic research community affects this industry in at least three ways. First, the general awareness of reduced funding for research as well as excellent opportunities in other disciplines (e.g., law and business) has led to shifts in career interest from science to other fields of endeavor, resulting in the loss of talented young
scientists. Second, as training grants are limited, the number of industry scientists will be reduced and the influx of investigators highly trained in state-of-the-art approaches to important research questions will decline as well. Third, we are at the dawn of a new era in basic research in which techniques such as molecular biology are rapidly expanding our vistas. To whatever extent basic research is limited by the federal government, the raw ideas that result in the generation of patents will be similarly limited. Data to predict the extent and rapidity of the adverse effects that will result from current federal funding policies are not available, but all indications are that progress will be markedly slowed.

4. What is the relation of foreign to domestic activities in basic research, and what is the impact of this relation on the scientific community and industry?

Stossel and Stossel have recently reported the countries of origin of what was considered high-quality clinical research. They reviewed papers published over a period of nearly 10 years in the New England Journal of Medicine, Journal of Clinical Investigation, Lancet, and Blood. The observed changes differed among the various journals, but overall, the proportion of papers originating outside the United States increased two- to threefold, with Japan and the countries of Western Europe being the major contributors. A similar phenomenon was seen at the AHA's 62nd annual Scientific Sessions in 1989. More than 8,000 abstracts were submitted for presentation. For the first time since Scientific Sessions data have been gathered, the number of submissions from the United States decreased (by approximately 4%), whereas those from foreign countries increased by 31%. Again, the greatest number came from Japan and Western Europe.

Given the information provided earlier in this report, it is reasonable to consider the impact of the increment in research activity outside the United States on the generation of patents both inside and outside the country. Recently published data indicate that 80% of patents filed in the United States until 1970 were derived from US sources. As of 1989, the US share has fallen to 50%. As seen in Figure 10, Japan's contribution to the patent market is climbing steeply and not at the expense of the Federal Republic of Germany, the United Kingdom, France, or other countries. This same tendency can be observed by reviewing the 1989 data from the Journal of Cardiovascular Patents, which reviews only patents considered particularly promising in the cardiovascular area. Thirty-eight percent of these patents were issued for US companies, 18% for Japanese companies, and the remaining 44% for other countries (primarily the Federal Republic of Germany, the United Kingdom, and France). While these figures are not sufficient to permit conclusions about trends in the development of promising cardiovascular patents, they do not demonstrate particular dominance on the part of the United States.

Perhaps the most telling data are those in Figure 11. Narin and Olivastro reviewed patent classes with more than 500 patents each and reported the change observed when comparing the United States and Japan from 1975 to 1979 and 1980 to 1984. The major share of patents was in the sector that identified a decline in the United States and an increase in Japan. It must be emphasized that this figure does not specifically relate to bioaffecting drugs, but rather, broad classes of patents. Nonetheless, the overall trend is unmistakable: The United States has lost its dominance.

In summary:
- There is a quantifiable relation between federal dollars spent on research funding and the number of scientific papers published.
The performance of basic research, including a sizeable subset with absolutely no clinical goals, is clearly necessary for advancement of clinical care.

The performance of basic research is a cost-effective means for reducing dollars lost in healthcare expenses and to the economy as the result of illness and death.

Compared with other competitive countries, US efforts are lagging in training of students and scientists and in the generation of scientific information and its industrial application.

While this report has focused on research related to treatment of cardiovascular disease, it has not addressed in corresponding detail research that has led to advances in diagnostic modalities. If a comparable analysis of that area were undertaken, a similar set of health care and economic arguments would probably be forthcoming.

Given these unmistakable trends, and despite the fact that the United States is still in a strong position, it is reasonable to assume that if federal support for research is not substantially increased, this country will be unable to sustain its leadership in research and development in many areas, including cardiovascular research. The United States will then have to look elsewhere for leadership in health care research and delivery as well as the economic gains that derive from and are associated with it. In fact, we will be purchasing from others that which we, to date, have provided with great success.

Early in the deliberations of the task force, it became clear that two different but not mutually exclusive approaches to the present crisis are available to the AHA. One involves rapid mobilization and reaction to the present crisis, directed at altering the nation about the dire impact of present federal research funding policies on this country’s health and economy. This effort was undertaken by the AHA on its own in the summer of 1990, with the goal of reversing federal funding restrictions, restoring research grant budgets to levels recommended by peer review committees, and increasing the funding base so that all grants graded outstanding, excellent, or good are funded. This result should be attained in a setting in which the current trend toward increased 5-year funding is maintained and in which cutbacks in training grants are reversed.

To achieve this goal, the Ad Hoc Group for Medical Research Funding has stated:

A stable base of funding will be achieved when we have assured a steady supply of new creative researchers who enter productive careers; supported the best ideas they propose as judged by merit review and award of the top 50% of approved grant applications; insured that retiring scientists are replaced to achieve a steady state; and provided proper equipment and facilities for this cadre of scientists. An optimal steady state will be achieved when the federal research effort is one quarter to one third larger in constant dollars than at present. Federal funding policy should be to increase the annual appropriations for both NIH and ADAMHA by 2–3% in real growth above the current services budget for that year. Thus the constant dollar budget base...would be 25–35% greater by the year 2000 than at present.

This goal for the NIH could satisfy the specific needs for cardiovascular research funding. Translated into fiscal year 1991 funding, the Ad Hoc group has recommended (and the AAMC has endorsed) an NIH budget of $9,237 billion ($1.6 billion greater than that in 1990 and $1.3 billion greater than that requested by the administration).

The second approach can be carried out solely by the AHA, but the task force views this as better performed with other interested and appropriate organizations. Succinctly stated, the United States needs a 10-year plan for research management. The current system, in which investigators and NIH institute directors alike are subject to the whims of the executive branch and Congress, is in disarray and unable to develop a plan. In fact, planning in the face of stringent budget cuts becomes a matter of attempting to survive rather than encouraging the reflection and innovation needed for scientific discovery.

This approach requires that a blue-ribbon panel be convened under the aegis of a group of organizations. The committee would produce a position paper directed at federal-level research management (targeted only to the NIH or to other agencies as well). Such a report would take 1 or 2 years to prepare. When adopted by the sponsoring organizations, it would be used to influence the executive and legislative branches of government to provide a more stable and hospitable environment for the growth of scientific research.

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