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The Surgical Scientist

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Progressively, during the last several years, there has been great concern about the endangered status of surgical research. This has resulted primarily from two perceptions: 1) funding for biomedical research, from the federal government and from nonfederal public and private funding agencies, has decreased in recent years and will continue to decrease in the future; and 2) current changes resulting from the corporate transition of medicine in the United States of America, characterized by the progressive and widespread intrusion of managed care, will result in less discretionary revenue for academic clinical departments. Recognizing that surgical research is critical to the clinical practice of surgery, I have chosen to speak about the "Surgical Scientist." The topic also has a personal appeal because during my professional career, I have derived great satisfaction from clinical investigation, and from working the interface between the laboratory and the patient, in my case, with the emphasis on the patient. Particularly, I will consider younger surgical scientists and what lies ahead for them because they are the ones who will advance the field by exceeding what we have done.

As a beginning house officer, I recognized the importance of basic laboratory investigation to advances in clinical medicine, and I soon learned that the outstanding departments of surgery were those that had excellent programs both in clinical surgery and laboratory research. In my role as Chairman of the Department of Surgery at Washington University, I have been associated with many outstanding house officers and faculty members. I have shared their frustrations and concerns about the present status and the future prospect of funding for surgical research, yet I uniformly have encouraged those with the commitment and the ability to pursue a career in surgical science. I have given such advice because the future in clinical medicine has great promise. The broad frontier of biomedical research is progressing at an awesome pace, and the opportunity to apply important laboratory discoveries to the care of patients never has been greater.

What is the current state of surgical research? What problems are facing our younger colleagues who are beginning their careers as surgeons and will someday be the leaders of this and other learned societies? Will the resources be available to support them during the critical phase of their development? Will young surgical scientists find themselves unable to compete with full-time laboratory investigators for research support and thereby be forced to choose between either clinical practice or "bench" research? Will the reduced reimbursement for clinical services introduced by managed care force academic departments of surgery to curtail their support of laboratory research for residents and young faculty members? Most of all, what can we do to help our younger colleagues be successful and in so doing maintain the viability of our profession? They will have a harder time of it than we had.

The development of the young surgical scientist is determined primarily by personal qualities and environment. Personal qualities can be defined more specifically in terms of intellect, integrity, ambition, motivation, etc. Environmental factors include the physical and emotional surroundings of our upbringing; the influence of parents, peers, and educators; financial support during medical school, the residency, and the early faculty years; and most importantly, the commitment and support of key figures such as the department chairman, senior faculty members, and scientific mentors.

PERSONAL QUALITIES

It seems obvious that one must have certain basic mental faculties and personal interactive skills to succeed as a clinical investigator. It is helpful to have the right parents, to be educated at the right college and medical school, to match the right surgical residency, and to join

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the right department of surgery at the right time. However, each of us can look around and see examples of many colleagues who have become excellent clinical investigators despite many of the mentioned ingredients not being "right." Actually, they seldom are.

It takes enormous discipline, commitment, and dedication to develop as a clinical investigator because there are so many distractions along the way. Fuller Albright wrote about this in a memorable discourse entitled, "Some of the 'Do's' and 'Do-Not's' in Clinical Investigation."[1] Of the "Do's," he recognized the importance of being born with a good intellect and an inquisitive mind, and he stressed the importance of being ambitious ("ambition breeds energy"), of being an original thinker, of having adequate research support, and of managing data by measuring something, making charts, and interpreting results accurately. He strongly recommended that the clinical investigator try to reserve some time during each day for "unadulterated thinking."

Among the "Do-Not's," he warned against too much skylight (lacking focus and being spread too thin), of being too ambitious, of working alone, of being secretive or rigid, and of being disturbed by pressure. Above all, he warned the aspiring clinical investigator not to "show too much administrative ability" lest he assume obligations that, although worthy, remove him from productive time in the laboratory.

Albright described a clinical investigator as one "trying to ride two horses—attempting to be an investigator and a clinician at one and the same time."[1] This equestrian trickery is risky but a necessity if the young investigator's bipartite effort is to be successful in defining important questions that are evident only to those who till the fertile ground of a busy clinical ward. The rider must constantly remember that he is riding two horses and that "overcommitment" to the clinic or to the laboratory will create an imbalance and end the ride. There also is the frustration that the clinical investigator can be neither as skilled a basic scientist as his colleagues who work full time in the laboratory, nor as good a clinician as his colleagues who are devoted solely to patient care. In this regard, it is particularly important that the surgical scientist learn to collaborate with basic scientists or clinical investigators in other disciplines if he is to solve successfully the clinical puzzle under study. Personally, such relationships have been fundamental to any success that I have had as a clinical investigator.

Dr. Francis Moore, a former President of this Association and a recipient of its Medallion for Scientific Achievement, described the surgical investigator as a "bridge tender, channeling knowledge from biological science to the patient's bedside and back again." He continued, "Those at one end of the bridge say he is not a very good scientist, and those at the other end say he does not spend enough time in the operating room. If only he is willing to live with this abuse, he can continue to do his job effectively."[2]

The management of time and effort is extremely problematic for the young surgical scientist. He is eager to apply his knowledge and technical skills to the management of patients with surgical problems, yet he realizes that the key to academic success comes through laboratory or clinical research. Clearly, the integrity of our specialty depends primarily on how well we care for our patients. If we are poor clinicians, the quality of the research that we do matters little. Some clinical departments in medical schools have considered laboratory research of primary importance and have de-emphasized patient care. These departments have excellent basic science programs, but their clinical operations—including their house staff training programs—have suffered. When key clinical departments develop research programs with such a singular purpose, a key balance is lost and often the character of the medical school is altered. In the current health-care climate, where changes are coming on us with startling rapidness, this imbalance presents a particular problem. All departments in academic medical centers will have to provide quality clinical services in an efficient, integrated, and cost-effective manner if they are to be competitive in the managed-care environment.

The clinical investigator must have the industriousness and the commitment to develop the necessary laboratory skills if he is to be successful. This matter was addressed well by Goldstein,[3] who described the plight of a young house officer who embarked on a promising career in clinical investigation after an important laboratory discovery. He took his observation to a certain point but could proceed no further because his progress was limited by "lack of appropriate training." Goldstein termed this shortcoming the "Paralyzed Academic Investigator's Disease Syndrome (PAIDS)" and noted that it could be prevented by a simple prescription consisting of a combination of solid training in basic science and a special quality that he called "technical courage." Technical courage is the "confidence and sense of adventure that emerges from sound basic science training; it is the courage to use new techniques to answer important questions; it is the courage to avoid fossilization in what one already knows."[3]

Goldstein gave examples of scientists who had demonstrated technical courage in making highly important scientific discoveries. One of these, the German pathologist Karl Landsteiner, has particular relevance to our consideration of the surgical scientist because during his most productive scientific period, he had an enormous clinical burden.[4] In the first decade of his profession as an anatomic pathologist, he performed more than 3600 autopsies—on average, one autopsy a day, 7 days a week, for 10 years. Despite this burdensome responsibility, it was during this time that Landsteiner made his most significant observations. His primary interest was in the phenomenon of massive tissue destruction and hemolysis that followed the infusion into hosts of foreign proteins and blood products. His work with the renowned chemist Emil Fischer prepared him for his laboratory experimentation, which led to the development of the field of immunochemistry and the discovery of the A, B, O blood groups.

There are many examples of past and present members of the American Surgical Association whose basic science training and technical courage have led to important discoveries in medicine. Alfred Blalock, during his years as a research fellow, a surgical resident, and a faculty member at Vanderbilt University, focused his laboratory investigation on studies of the physiology and pathophysiology of the cardiovascular system. Particularly, his research on circulatory shock was highly important and brought him broad recognition as an innovative surgical scientist. Also, his laboratory experimentation served as the basis for the operative treatment of children with cyanotic heart disease during his tenure as Chair of the Department of Surgery at the Johns Hopkins University School of Medicine.[5] Evarts Graham credits his work on the development of cholecystography to a "more extensive training in chemistry than was usual for the members of the medical profession and especially for a surgeon." He wrote, "I gave up my small surgical practice and spent the years of 1913 and 1914 at the University of Chicago in the study of chemistry. The time so devoted was fruitful to the extent that it enabled me to take advantage of the possibilities of the application of some relatively simple chemistry to the problem of the improved diagnosis of gallbladder disease."[6] Lester Dragstedt was first a physiologist and then a surgeon with a strong background in basic laboratory investigation. His animal experiments on gastric physiology and the function of the vagus nerve were extended to the clinic and established the place of vagal denervation in the treatment of patients with peptic ulcer disease.[7]

A surgical scientist should note the essentialness of being well trained in basic science methodology and in applying it to the specific clinical problem at hand. Accordingly, in developing a successful research program, the surgical scientist may find it necessary to learn certain laboratory techniques from his basic science colleagues. At the outset, the surgical investigator may spend more time working with tissue culture cells, fruit flies, transgenic mice, pigs, or primates than with humans, but such fundamental preparation is a necessary component of clinical investigation.

I have five recommendations for young surgical scientists:

1. The most important time in your professional career is the first 5 years after completion of the surgical residency. It is during this time that you must obtain a position on the faculty of a progressive department of surgery, develop your laboratory research program and secure extramural peer review funding to support it, and maintain your clinical skills.
2. Develop a highly focused yet integrated research program in which your clinical interest and your basic laboratory interest are complementary.
3. Learn to collaborate with those who know more than you and with those who are better scientists than you.
4. If your submitted research grant is not funded on the first try, revise the grant by responding to the critique and resubmit it on the next cycle. This exercise may need to be repeated more than once. Often the only personal characteristic separating the successful from the unsuccessful surgical scientist is *perseverance.*
5. Work hard and deny yourself the readily obtainable comforts of life.

ENVIRONMENTAL FACTORS

Funding of Medical Education

One of the early and persistent concerns regards finances. The problem usually is encountered when one applies to medical school. The costs of a medical education are staggering, and few families can bear the financial burden required for 4 years of medical education and related expenses. Almost all medical students must either depend on scholarships or borrow a large sum of money to complete their medical education.

Students who graduated from medical school in the United States in 1994 had an average indebtedness of $56,702. The Washington University School of Medicine graduated 116 medical students in 1990–1991. The 77 students who obtained loans for their medical education had an average indebtedness of $43,008, and 14 of them owed $60,000 or more (Table 1). By 1995–1996, 88 medical students had obtained financial loans (their average indebtedness was $55,103), and 38 of them owed $60,000 or more.[8] This increased indebtedness has been due to inflation, to increases in tuition (almost 30% during the 5-year period), and to the raised ceiling ($25,000) on Stafford loans provided by the federal government. Furthermore, medical students currently are beginning residencies at a time when the government will be providing less reimbursement to hospitals for the support of postgraduate education. Most physicians will earn less money than their predecessors. Finally, there will be fewer physician positions available (especially in the specialty sector). It is a wonder that any of our bright young

Table 1. COMPARISON OF AVERAGE INDEBTEDNESS OF WASHINGTON UNIVERSITY MEDICAL STUDENTS GRADUATING IN 1991 AND 1996

Graduates' Average Debt	1990–1991	1995–1996
1–$19,999	13	12
20,000–29,999	10	7
30,000–39,999	13	14
40,000–49,999	10	7
50,000–59,999	17	10
60,000–69,999	6	7
70,000–79,999	4	11
80,000–89,999	1	6
90,000–99,999	2	8
>$100,000	1	6
Total	77	88
National average debt ($)	50,384	NA
WUMS average debt ($)	43,008	55,103

NA = not available; WUMS = Washington University Medical Students.

medical students elect the arduous and lengthy residencies required for training in general surgery or the surgical specialties.

Funding for Biomedical Research

There is great concern from scientists of all disciplines, and at every stage of development, regarding the biomedical research funding from the National Institutes of Health (NIH) and from other nonfederal and private funding agencies. There is the general perception, and in some cases ample data to support it, that there has been a marked reduction in the level of research support from these conventional sources during the last 5 to 10 years. I sought to determine funding patterns of three agencies that are important sources of support for surgical research: the American Cancer Society (ACS), the Veterans Administration (VA), and the NIH.

At the outset, I had three premonitions regarding research funding from these sources: 1) financial support for biomedical research had decreased during the last 5 to 10 years; 2) surgeons, compared with other clinical specialists, had experienced greater reductions in research support; and 3) in clinical departments, an increasing proportion of research grants were awarded to doctors of philosophy (PhDs), compared with medical doctors (MDs), and the trend was particularly prevalent in departments of surgery.

Conventional Sources of Funding

The American Cancer Society

Funding patterns in the ACS from 1991 through 1995 were reviewed for six clinical departments: Internal Medicine, Obstetrics and Gynecology, Pathology, Pediatrics, Radiology, and Surgery.

The total budget of the ACS in 1991 was $362,296,000, and $97,281,000 (27%) of the total was appropriated for Research Awards and related expenses.[9] In 1995, the total budget of the ACS had increased to $384,804,000, but only $92,153,000 (24%) of the total was appropriated for Research Awards and related expenses.[10] From 1991 through 1995, the level of funding for Research Project Grants to investigators in the six clinical departments decreased 16%, from $9,287,256 to $7,801,500 (Fig. 1). In 1991, 67 (23%) of 286 submitted grants were funded, whereas in 1995, only 60 (14%) of 429 submitted grants were funded. Although the number of submitted grants from investigators in the six clinical departments increased only 15% from 1991 through 1994 (328 grants were submitted in both 1993 and 1994), the number of grants submitted in 1995 increased 50%, compared with 1991, and 39%, compared with 1994. Even though the percentage of total grants submitted by PhDs remained roughly the same from 1991 through 1995 (47% *vs.* 46%), the percentage of funded grants awarded to PhDs increased 52%, from 33% to 50%.

During this same time period, the data for Internal Medicine and Pediatrics were similar. The percentage of submitted grants that were awarded decreased 38%, from 37% to 23%, in Internal Medicine (Fig. 2A) and 42%, from 33% to 19% in Pediatrics (Fig. 2B). The percentage of PhDs who submitted research grants varied from 21% to 35% in these two specialties during the 5-year period. The proportion of funded grants that were awarded

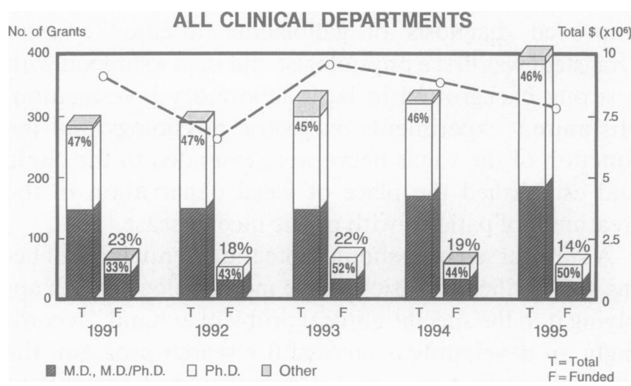

Figure 1. Data from the American Cancer Society showing total funding for Research Project Grants for the clinical departments: Obstetrics and Gynecology, Pathology, Pediatrics, Internal Medicine, Radiology, and Surgery from 1991 through 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years.

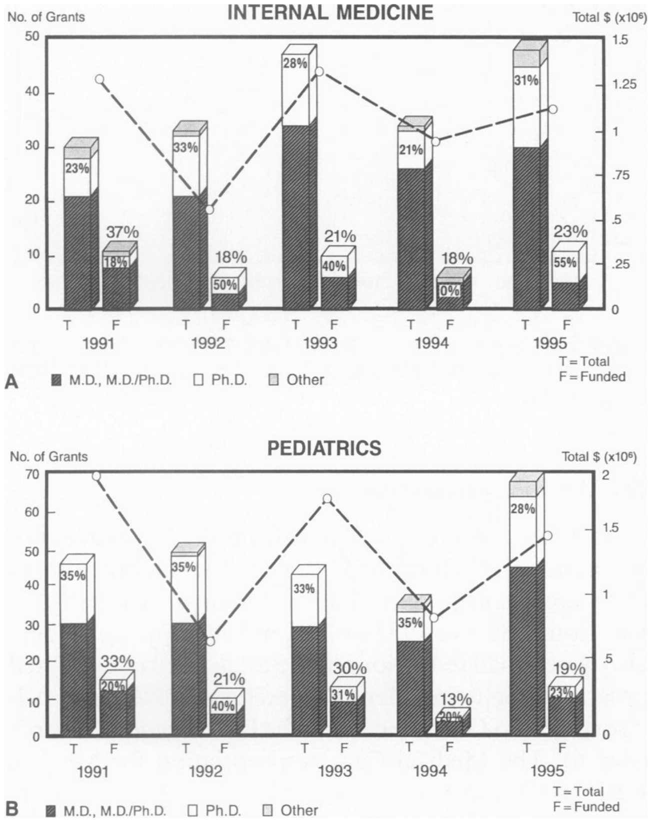

Figure 2. (A) Data from the American Cancer Society showing funding for Research Project Grants for Internal Medicine from 1991 through 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years. (B) Data from the American Cancer Society showing funding for Research Project Grants for Pediatrics from 1991 through 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years.

to PhDs increased more than 200%, from 18% to 55%, in Internal Medicine. During the same time period, the percentage of funded grants awarded to PhDs in Pediatrics varied substantially but was approximately the same in 1991 (20%) and in 1995 (23%).

In Pathology, there also was an increase in the numbe· of grants that were submitted in 1995 compared with 1991, but the percentage of grants awarded during this period decreased 38%, from 21% to 13%. The percentage of total grants submitted from PhDs during this time period was constant, at approximately 50%; however, the percentage of funded grants awarded to PhDs increased 43%, from 42% to 60% (Fig. 3A).

In Radiology, at least 60% of the grants submitted during the 5-year period were from PhDs, and in 1991, 1993, and 1995, all of the funded grants were awarded to PhDs (Fig. 3B). The percentage of submitted grants that were awarded was no higher than 24% in any year, and it was as low as 9% in 1991 and 1995.

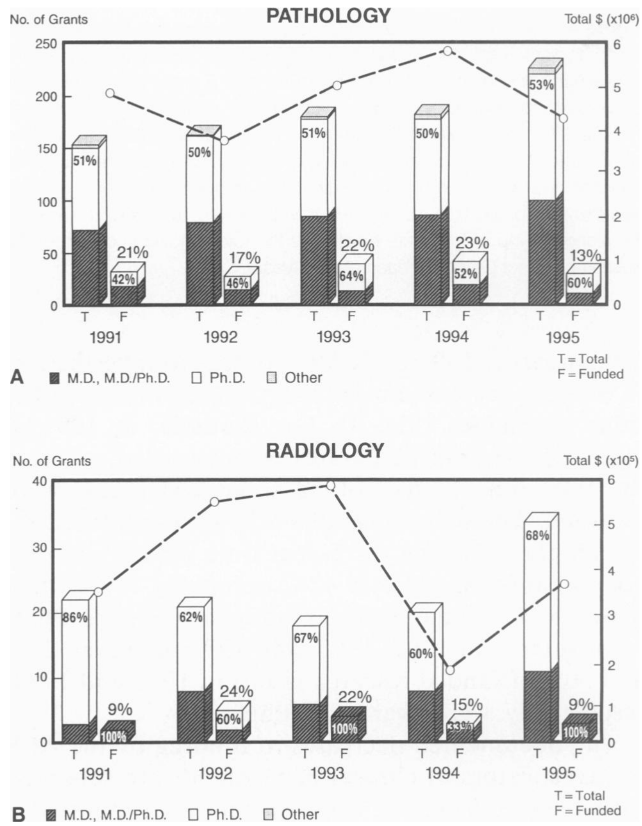

Figure 3. (A) Data from the American Cancer Society showing funding for Research Project Grants for Pathology from 1991 through 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years. (B) Data from the American Cancer Society showing funding for Research Project Grants for Radiology from 1991 through 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years.

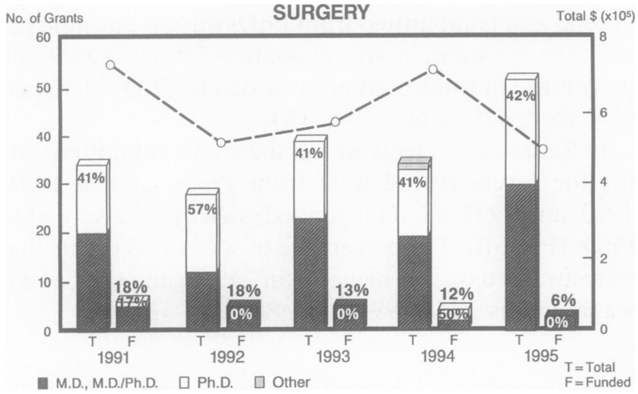

Figure 4. Data from the American Cancer Society showing funding for Research Project Grants for Surgery from 1991 through 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years.

Comparing 1991 and 1995, awards to investigators in Surgery decreased more sharply (66%) than for the other specialties (Fig. 4). For example, in 1991, 6 (18%) of 34 submitted grants were awarded, whereas in 1995, only 3 (6%) of 52 submitted grants were awarded. The percentage of PhDs who submitted research grants during the 5-year time period was very consistent (either 41% or 42%, except for 1992, when it was 57%). There were no grants awarded to PhDs from surgery in 1992, 1993, and 1995; however, 17% and 50% of funded research grants in 1991 and 1994, respectively, were awarded to PhDs.

The documented decreases in funding by the ACS to investigators in clinical departments are sobering. Investigators from the six departments submitted a greater number of grants in 1995 compared with 1991, but overall there was a 39% decrease in the percentage of submitted grants that were awarded during this time. Investigators in Departments of Surgery compared poorly with investigators in other clinical specialties. However, the specialty of Surgery had the smallest percentage of funded grants awarded to PhDs, although a substantial number of PhDs from Departments of Surgery applied to the ACS for grant support.

There is a silver lining to this cloud. On February 1, 1996, the ACS changed its policy for applications for Research Project Grants to emphasize the funding of younger investigators. The guidelines read as follows: "individuals seeking project-related research support may apply for funding from the American Cancer Society at any time within **eight** years of their first independent research or faculty appointment."[11]

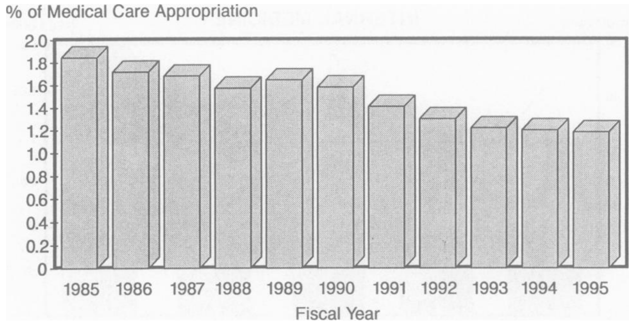

Figure 5. Data from the Veterans Administration showing the percent of the Medical Research Service appropriated to medical care from 1985 through 1995.

The Veterans Administration

According to a review of data from the Department of Veterans Affairs, there had been a reduction in the Medical Care Appropriation for the Medical Research Service from 1.85% in 1985 to 1.2% in 1994 (Fig. 5).[12] There also were broad reductions in the total number of funded programs, including Merit Review Grants, Research Advisory Group Grants, and Career Development Awards (Fig. 6). The Medical Care Appropriation for Medical Research in the VA (excluding rehabilitation research, prosthetic research, and health systems research) for 11 clinical disciplines (Anesthesiology, Dermatology, Internal Medicine, Neurology, Ophthalmology, Orthopedics, Otolaryngology, Pathology, Psychiatry, Radiology, and Surgery; as defined by the principal investigator's hospital service) was $134,123,472 in 1990, and it increased 3.8% to $139,194,145 in 1995. Compared with 1995, the budgets for Medical Research in almost all of these 11 disciplines had been higher in each preceding year, except 1990 and 1992. Comparing dollars awarded to the 11 disciplines, in the 1990 year and the 1995 year, four experienced a decrease and seven experienced an increase (Table 2). The highest percentage increases in funding during this 6-year period were in Ophthalmol-

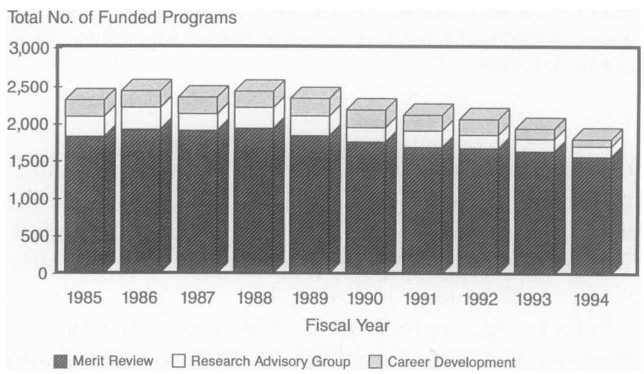

Figure 6. Data from the Veterans Administration showing the total number of funded programs and types of programs from 1985 through 1994.

Table 2. COMPARISON OF FUNDING IN 1990 AND 1995 FROM THE VETERANS ADMINISTRATION INCLUSIVE OF MERIT REVIEW GRANTS, RAG GRANTS, AND CAREER DEVELOPMENT AWARDS

Department	% Change
Radiology	−59
Otolaryngology	−16
Medicine	−4
Orthopedic surgery	−4
Pathology	+3
Dermatology	+9
Anesthesiology	+9
Psychiatry	+12
Neurology	+30
Surgery	+38
Ophthalmology	+64

* RAG = Research Advisory Group.

ogy (64%) and Surgery (38%). The largest reductions in grant dollars awarded during this time period were in the disciplines of Radiology (59%) and Otolaryngology (16%). No data were reviewed comparing the proportion of awards to MDs and PhDs during this time period. The total number of reviewed and funded Career Development Awards in the VA from 1979 to 1994 is shown in Table 3. Except for the disciplines of Respiration, Oral Biology, and Anesthesiology, Surgery and Mental Health had the lowest success rates of funding.

The National Institutes of Health

The NIH funding data from 1984 through 1995 were reviewed for the following clinical departments: Anesthesiology, Dermatology, Family Practice, Internal Medicine, Neurology, Obstetrics and Gynecology, Ophthalmology, Orthopedic Surgery, Otolaryngology, Pediatrics, Physical Medicine and Rehabilitation, Public Health and Preventive Medicine, Psychiatry, Radiology, Surgery, and a category of "other clinical sciences,"—departments that included programs with titles such as clinical studies, special clinical sciences, and clinical research program. Only investigator-initiated grants, such as RO1 grants, PO1 grants, R-29 grants, and R-37 grants, were included. All grants were either Type-1 (new research grants), Type-2 (competing renewal grants), or Type 3 (grant supplements). Noncompeting renewal grants were not included. Also, funding vehicles such as Training Grants, Center Grants, and Career Development Award type Grants were not included.

The total dollars awarded to investigators in the 16 clinical disciplines increased 110%, from $211,945,000 in 1984 to $446,239,000 in 1995 (Fig. 7). The number of submitted grants increased 52%, from 4767 in 1984 to 7264 in 1995. However, the number of submitted grants that were awarded increased only 24%, from 1492 in 1984 to 1842 in 1995. The percentage of submitted grants that were awarded during the 12-year period decreased by 19% from 31% in 1984 to 25% in 1995. The percentage of total grants submitted by PhDs increased 10% from 40% in 1984 to 44% in 1995, although there was modest variability around these numbers from year to year. The percentage of the funded grants that were awarded to PhDs increased 5% from 40% in 1984 to 42% in 1995, there again being modest variability in the percentages of this proportion during the intervening years. Because of the large number of clinical specialties under consideration, we will review data in more detail from seven departments: Anesthesia, Internal Medicine, Obstetrics and Gynecology, Ophthalmology, Pediatrics, Radiology, and Surgery.

The funding patterns for Internal Medicine and Pediatrics were similar to each other (Fig. 8). From 1984 to 1995, the number of submitted grants in Internal Medicine that were awarded decreased (16%) from 32% to 27% (Fig. 8A). There was a 10% increase in the percentage of PhDs applying for research grants during this time period, but the percentage of funded grants that were awarded to PhDs essentially was unchanged. In 1984, $92,196,000 were awarded to support 623 grantees whereas in 1995, $186,576,000 were awarded to support 757 grantees. In each of the 12 years, Internal Medicine,

Table 3. COMPARISON BY SPECIALTY OF REVIEWED AND FUNDED CAREER DEVELOPMENT AWARDS FROM THE VETERANS ADMINISTRATION FROM SPRING 1979 TO FALL 1994

Specialty	Total Reviewed	Total Funded	Succes Rate (%)
Ophthalmology	3	2	67
Neurology	158	64	41
Dermatology	35	14	40
Gastroenterology	316	118	37
Endocrinology	387	144	37
Hematology	204	75	37
Immunology	263	93	35
Oncology	145	50	35
Cardiology	283	97	34
Nephrology	300	102	34
Audiology	3	1	33
Infectious Diseases	257	85	33
Biochemistry	46	13	28
Nuclear Medicine	137	36	27
Mental Health	22	6	26
Surgery	92	24	26
Respiration	250	63	25
Oral Biology	37	63	25
Anesthesiology	23	4	17
Total	2961	998	34

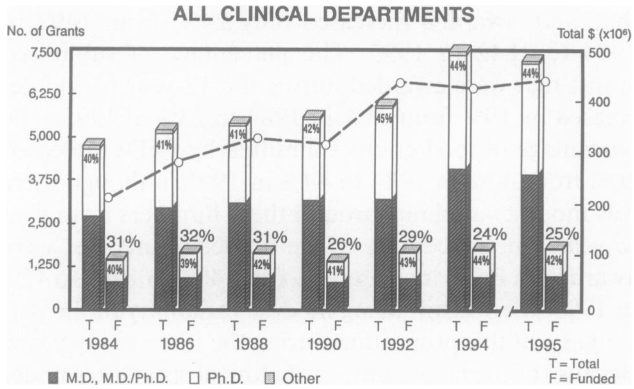

Figure 7. Data from the National Institutes of Health showing funding for the clinical departments: Anesthesiology, Dermatology, Family Practice, Internal Medicine, Neurology, Obstetrics and Gynecology, Ophthalmology, Orthopedic Surgery, Otolaryngology, Pediatrics, Public Health and Preventive Medicine, Psychiatry, Radiology, Physical Medicine and Rehabilitation, Surgery, and other clinical sciences from 1984 through 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years.

compared with the other clinical disciplines, had the largest number of grants submitted, the largest number of grants awarded, and the largest number of dollars awarded.

In Pediatrics, the percentage of submitted grants that were funded decreased 18%, from 28% in 1984 to 23% in 1995 (Fig. 8B). Both the percentage of PhDs submitting grants and the percentage of funded grants awarded to PhDs varied somewhat, but there was no change in either category in 1984 compared with 1995.

The disciplines of Obstetrics and Gynecology, Ophthalmology, and Radiology had somewhat similar patterns of funding during the 12-year period (Fig. 9). In Obstetrics and Gynecology, there was a 13% increase in total dollars awarded, from $7,105,000 to $8,013,000 (Fig. 9A). In Ophthalmology, there was a 10% increase in funding, from $12,596,000 to $13,897,000 (Fig. 9B). In Radiology, there was a 35% increase in funding, from $17,298,000 to $23,385,000 (Fig. 9C). The total number of grants submitted during this period increased 12% in Obstetrics and Gynecology (Fig. 9A) and 104% in Radiology (Fig. 9C). However, there was a 10% decrease in the number of grants submitted from investigators in Ophthalmology (Fig. 9B). The majority of grants submitted from these three disciplines were from PhDs, and the majority of funded grants were awarded to PhDs. The percentage of total submitted grants that were awarded decreased in each of these disciplines during the 12-year period, from 24% to 16% (33%) in Obstetrics and Gynecology, from 48% to 32% (33%) in Ophthalmology, and from 37% to 21% (43%) in Radiology.

In the specialty of Anesthesiology, there was a 171% increase in the number of grants submitted, from 69 in 1984 to 187 in 1995 (Fig. 10A). During this same time period, there was a similar (175%) increase in dollars awarded to Departments of Anesthesiology, from $3,089,000 in 1984 to $8,491,000 in 1995. The percentage of grants that were awarded during this period de-

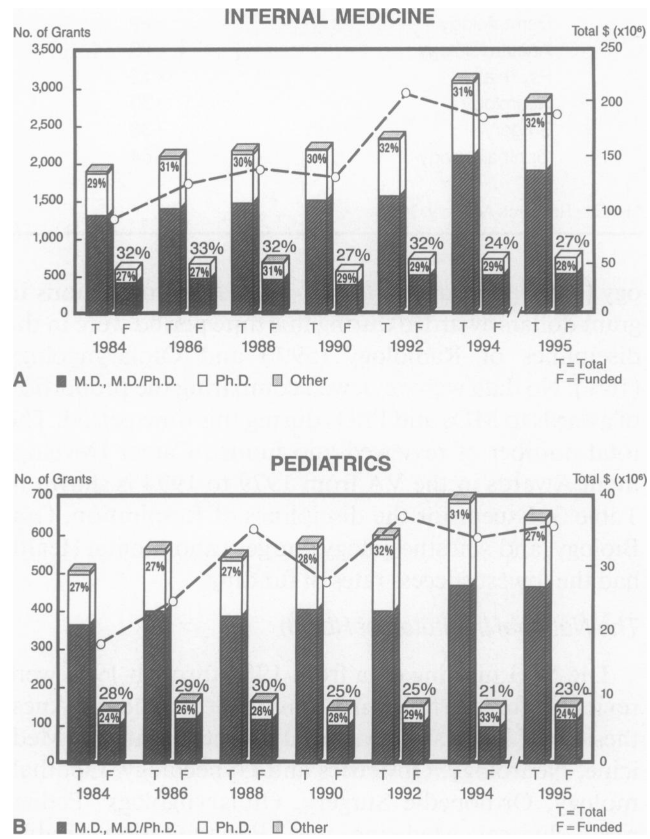

Figure 8. (A) Data from the National Institutes of Health showing the funding for Departments of Internal Medicine from 1984 through 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years. (B) Data from the National Institutes of Health showing funding for Departments of Pediatrics from 1984 to 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years.

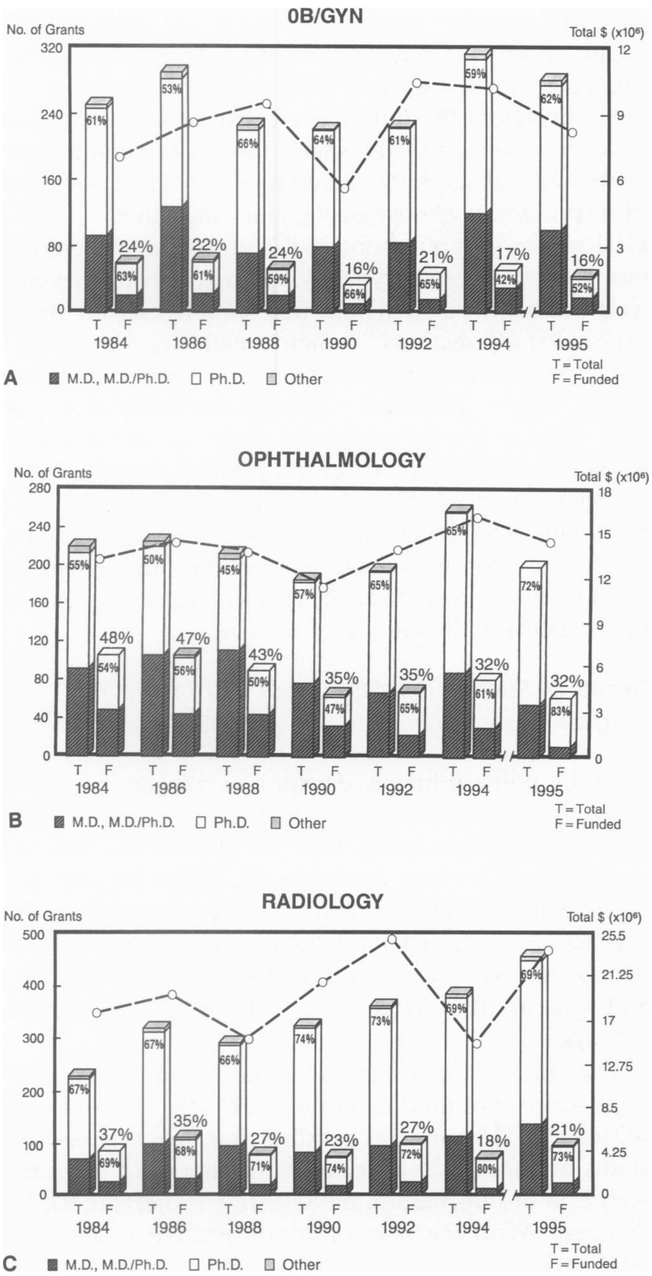

Figure 9. (A) Data from the National Institutes of Health showing funding for departments of Obstetrics and Gynecology from 1984 to 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the five years. (B) Data from the National Institutes of Health showing funding for Departments of Ophthalmology from 1984 to 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years. (C) Data from the National Institutes of Health showing funding for Departments of Radiology from 1984 to 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years.

creased 22%, from 32% in 1984 to 25% in 1995. The percentage of grants submitted by PhDs ranged from 55% to 42%, but actually decreased 11%, comparing 1984 to 1995. The percentage of funded grants that were awarded to PhDs varied modestly during the 12-year period but was greater than 50% in every year except for 1988 and 1990.

In the discipline of Surgery, there was a 42% increase in the number of grant applications submitted, from 473 in 1984 to 670 in 1995 (Fig. 10B). However, during this same time period, the grant dollars awarded to Surgery increased 135%, from $16,534,000 in 1984 to $38,839,000 in 1995. The percentage of submitted grants that was awarded varied moderately during the 12-year period but was the same in 1984 and 1995. The percentage of PhDs submitting grants increased 25%, from 36% in 1984 to 45% in 1995; however, of the grants funded during this time period, the percentage awarded to PhDs increased only 8%, from 39% in 1984 to 42% in 1995.

From 1984 through 1995, if one compares among the seven specialties under consideration the changes in total grants submitted, total grants awarded, and total dollars awarded, investigators in Surgery performed well (Table 4). Although surgical investigators experienced only the fourth largest increase in the number of grants submitted, they had the second largest increase in the number of grants awarded, and the second largest increase in the amount of grant dollars awarded. The percentages of total submitted grants that were awarded in both 1984 and in 1995 and the respective differences in the percentage of grants awarded in the 2 years are shown in Table 5. Of the 11 clinical disciplines shown, Surgery and Neurology experienced no decrease in the percentage of submitted grants that were funded. Only Otolaryngology had an increase in the percentage of grants funded in 1995 compared with 1984.

Overall, the results of the evaluation were surprising. Although there had been substantial reductions in re-

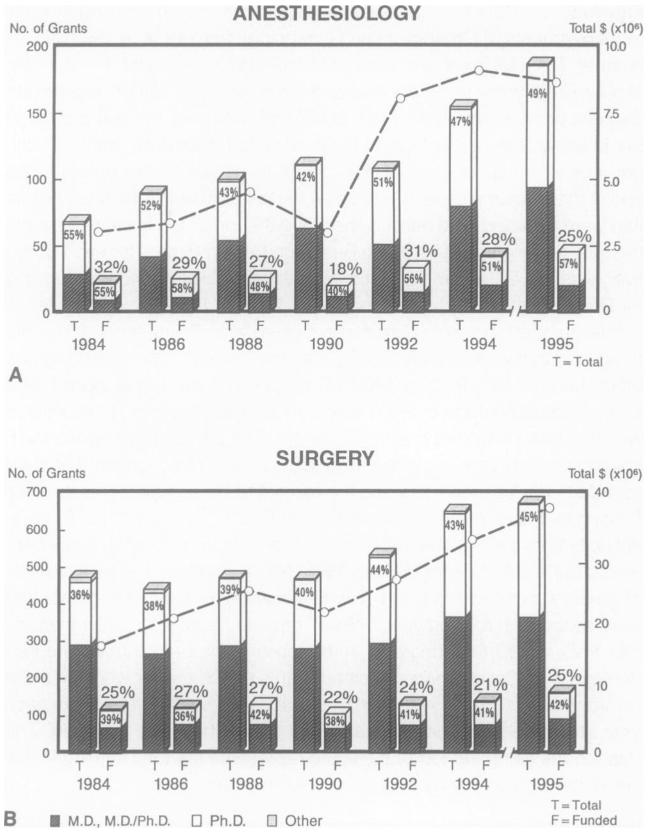

Figure 10. (A) Data from the National Institutes of Health showing funding for Departments of Anesthesiology from 1984 to 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the proportion of submitted grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years. (B) Data from the National Institutes of Health showing funding for Departments of Surgery from 1984 to 1995. No. = number; T = total number of grants submitted in a given year; F = number of submitted grants that were awarded in a given year; "other" represents degrees other than the MD, PhD, or MD/PhD degrees. In the top of each bar is shown the percentage of PhDs who had submitted grants (T column) or who had been awarded grants (F column). The percentages above the F column in each year show the number of proportion grants that were awarded. The dashed line along the top of the figure represents the total funding in dollars of the Research Project Grants for each of the 5 years.

sources provided by the ACS and only modest increases in support provided by the VA (an actual decrease in constant dollars), the actual research dollars awarded by the NIH had increased. Nevertheless, from each of these sources of funding, the proportion of submitted grant applications that were awarded had decreased over the years in almost all specialties. Except for the ACS, the discipline of Surgery had done relatively well compared with the other medical disciplines. Considering support for the types of investigators in Surgery, data from the ACS and the NIH showed that there was either no increase or only a moderate increase in the percentage of funded grants that were awarded to PhDs.

On occasion, the NIH has created *ad hoc* study sections of certain specialty groups to consider grants submitted by that specialty, including *ad hoc* study sections of surgeons to review surgical grants. Such an *ad hoc* surgical review group was formed in response to the criticism that extant Surgery Study Sections were too heavily weighted with PhDs. There were problems with these "special study sections," which usually were more significant than those experienced with the standard methods of review. Therefore, the NIH administration has used *ad hoc* review groups sparingly in recent years. Rather than take such a defensive position with the funding agencies, it would seem a sounder strategy for Departments of Surgery to provide house officers and junior faculty members with the time, resources, and, environment necessary to acquire the requisite research skills to be competitive for peer review funding.

Research Support for Members of The American Surgical Association

At this point, it might be helpful to consider how well the members of the American Surgical Association have done as surgical scientists. One would think that the Association has a strong record in this regard because the Membership Committee places such great emphasis on excellence in research and scholarship. How have members of the American Surgical Association performed, and what are the characteristics of our most successful colleagues?

The most important—and the most commonly used—source of funding at the NIH is the investigator-initiated RO1 grant. It is possible to review the funding status of an individual scientist through the Computer Retrieval of Information on Scientific Projects (CRISP) database. With the help of administrative staff at the NIH and through review of the CRISP database, it was found that 119 members of this Association presently serve as the principal investigator on some type of NIH grant. In 1994–1995, 43 members of the Association were Principal Investigators of an RO1 grant that had been funded continuously for 10 years or more. Twenty-three of the 43 members had been funded continuously for 15 years or more. Seven of the 43 members had MERIT (Method to Extend Research in Time) status of their grants, (funding for a 7-year period without competitive renewal). Not included in the search were surgeons who were principal investigators of other types of grants, such as Program Project Grants or Training Grants. Also, surgeons were not included if their continuous RO1 funding for 10 or more years was with overlapping grants, if they had a no-cost extension of their

Table 4. COMPARISON OF NATIONAL INSTITUTES OF HEALTH FUNDING TO SEVEN CLINICAL DEPARTMENTS FOR 1984 AND 1995: NUMBER OF GRANT APPLICATIONS, NUMBER OF GRANT APPLICATIONS AWARDED, AND TOTAL DOLLARS AWARDED

	No. of Applications			No. of Applications Awarded			Dollars Awarded		
Department	1984	1995	% Change	1984	1995	% Change	1984	1995	% Change
Anesthesiology	69	187	+171	22	46	+110	3,089,000	8,491,000	+175
Radiology	228	457	+100	85	95	+12	17,298,000	23,385,000	+35
Medicine	1920	2851	+49	623	757	+22	92,196,000	186,576,000	+103
Surgery	473	670	+42	119	164	+38	16,534,000	38,839,000	+135
Pediatrics	508	648	+28	143	151	+6	17,692,000	35,724,000	+102
Obstetrics/Gynecology	252	282	+12	60	46	−23	7,105,000	8,013,000	+13
Ophthalmology	221	200	−10	107	64	−40	12,596,000	13,897,000	+10

grant, if their grant had a change in its number or the name of the funding institution.

The purpose of the search was to identify a subset of surgical scientists with demonstrated continued productivity. The 23 members of the Association who had continuous funding for 15 or more years each were personally interviewed by the author and asked the same panel of questions.

The medical schools attended by the 43 members of the Association with continuous funding for 10 years or more are shown in Table 6, and the institutions at which they completed their residency education are shown in Table 7. The areas of their main clinical interest are shown in Table 8.

Of the 23 surgeons with a continuously funded RO1 grant for 15 years or longer, 16 entered medical school planning to pursue a career in clinical practice whereas 7 already had decided on a career in research. These surgeons developed a serious interest in research either in high school (2), in medical school (10), during surgical residency (10), or after the surgical residency (1). The person who served as the primary stimulus for them to pursue a career in laboratory investigation was either a high school teacher (2), a nonsurgical scientist (6), a chair

Table 5. DECREASES OR INCREASES IN NATIONAL INSTITUTES OF HEALTH FUNDING FOR CLINICAL DEPARTMENTS COMPARING 1984 AND 1995

	Success Rate*		
	1984	1995	Change
Ophthalmology	49	32	−16
Dermatology	43	28	−15
Radiology	37	21	−16
Orthopedic Surgery	29	15	−14
Family Practice	27	16	−11
Obstetrics/Gynecology	24	16	−8
Anesthesiology	32	25	−7
Public Health and Preventive Medicine	33	26	−7
Internal Medicine	32	27	−5
Pediatrics	28	23	−5
Psychiatry	30	28	−2
Surgery	25	25	0
Neurology	27	27	0
Otolaryngology	26	29	+4

* Success rate refers to the percentage of submitted grants that were awarded.

Table 6. MEMBERS OF THE AMERICAN SURGICAL ASSOCIATION WITH A CONTINUOUSLY FUNDED NATIONAL INSTITUTES OF HEALTH RO1 GRANT FOR 10 OR MORE YEARS

Medical School	No. of Members
Harvard University	8
Cornell University	3
University of Michigan	3
University of Texas	3
University of Maryland	2
Marquette University	2
University of Pennsylvania	2
University of California, San Francisco	2

1 Each:

Albert Einstein University; Boston University; Columbia University; Creighton University; Duke University; Hebrew University, Jerusalem; Johns Hopkins University; National Defense Medical Center, Taiwan; Northwestern University; Pahlavi University, Iran; State University of New York (Downstate); Tulane University; University of Cincinnati; University of Munich; University of North Carolina; University of Rochester; University of South Carolina; University of Tennessee; University of Texas, Southwestern

Table 7. MEMBERS OF THE AMERICAN SURGICAL ASSOCIATION WITH A CONTINUOUSLY FUNDED NATIONAL INSTITUTES OF HEALTH RO1 GRANT FOR 10 OR MORE YEARS

Surgical Residency	No. of Members
Hospital of the University of Pennsylvania	5
Massachusetts General Hospital	5
Presbyterian Hospital, New York	3
Brigham and Women's Hospital	2
Johns Hopkins Hospital	2
University of Utah	2
University of California, San Francisco	2
University of Minnesota	2

1 Each:

Beth Israel Hospital; Boston University; Case Western Reserve; Duke University; George Washington University; Jackson Memorial Hospital, Miami; New York Hospital; Parkland Hospital; St. Louis University; Tufts University; United States Public Health Service, New Orleans; University of Alabama; University of California, Los Angeles; University of Cincinnati; University of Michigan; University of North Carolina; University of Virginia; University of Wisconsin; Vanderbilt University; Yale University

of a Department of Surgery (6), a senior surgical scientist other than the department chairman (7), or a colleague (2). (Interestingly, the colleague cited by two surgeons was the same individual, and 1 of the 23 surgeons.) The surgeons spent a mean of 3.13 years (median 3 years) in laboratory investigation before they applied for their first NIH grant, and all but one of them had their grant funded on the first submission. When asked what they considered the most productive period of their investigative career, the majority picked a rather narrow period spanning 2 or 3 years; however, eight said that they had experienced two periods of high productivity, often several years apart (Fig. 11).

Table 8. MEMBERS OF THE AMERICAN SURGICAL ASSOCIATION WITH A CONTINUOUSLY FUNDED NATIONAL INSTITUTES OF HEALTH RO1 GRANT FOR 10 OR MORE YEARS

Field of Research	No. of Members
Cardiac Surgery	12
Transplantation	8
Gastrointestinal Surgery	7
Critical Care/Trauma	4
Surgical Infection	4
Metabolism	3
Vascular Surgery	2
Molecular Biology	2
Neurosurgery	1

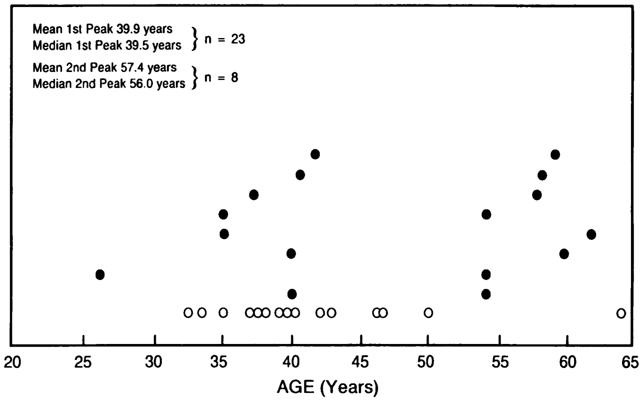

Figure 11. Period of peak productivity of the 23 members of the American Surgical Association who had continuous funding of the same National Institutes of Health RO1 grant for 15 years or more. Fifteen of the surgeons identified a single period of productivity (open dots), whereas eight surgeons reported two periods of high productivity (closed dots). For these eight surgeons, two dots on the same plane indicate the first and second periods of peak productivity.

At the time of the interview, each of the 23 surgeons maintained an enthusiasm for laboratory investigation and almost all had no plans to terminate their grants, although one recently had transferred the grant to an associate investigator. Each of the 23 surgeons had supervised numerous house officers, medical students, and fellows in the laboratory during their careers. Most believed that the current junior scientists were bright and had an excellent fundamental knowledge of basic science and computers. Conversely, others believed that current residents and fellows were more interested in laboratory research as a means to further their career than as preparation for being a surgical scientist. All 23 surgeons, except for 1, stated that if asked today, they would advise motivated surgical house officers or young faculty members to pursue careers in laboratory investigation.

Alternate Sources of Funding

It also is evident in reviewing data from the ACS, the VA, and the NIH that financial support for biomedical research from many of the standard sources is decreasing and that procurement of research funds is highly competitive. Basic scientists and clinical investigators have begun to turn to other sources of support for their research programs. These alternate sources of funding have most commonly come from professional societies, from special endowments established within medical schools or research institutions, or from industry.

The Orthopedic Research and Education Foundation

Recently and with increasing frequency, professional societies have assumed a major role in generating monies for clinical and laboratory research. An excellent example of such a philanthropic program in a medical society and a model for other professional and academic societ-

Table 9. WISCONSIN ALUMNI RESEARCH FOUNDATION LEADING MONEY-EARNERS

Date of First Patent	Invention	Principal Investigator	Department
08/14/28	Vitamin D Irradiation	Harry Steenbock[16]	Agricultural Chemistry
09/13/32	Copper-Iron Complex	E. B. Hart[18]	Agricultural Chemistry
09/16/47	Anticoagulants	Karl Paul Link[17]	Biochemistry
08/11/53	Coating Process	Dale Wurster[19]	Pharmacy
12/25/62	Fungicide	Stanley Knight[20]	Bacteriology
08/23/71	Vitamin D Derivatives	Hector DeLuca[21]	Biochemistry
05/20/80	Digital Vascular Imaging	Charles Mistretta[22]	Radiology and Medical Physics
01/10/83	NMR Scanning	Paul Richard Moran[23]	Radiology and Medical Physics
09/08/86	Wisconsin Solution	Folkert Belzer[24]	Surgery

NMR = nuclear magnetic resonance.

ies to emulate is the Orthopedic Research and Education Foundation (OREF), established in 1955.[13] In 1995, the OREF raised $4,333,109, the largest portion of which represented donations from individual orthopedic surgeons (52.3%) and corporations (35.6%). There were 1492 orthopedic surgeons who each donated $1,000 or more to the OREF. The monies raised were used to support several activities, such as Research Grants (15 grants at $50,000 a year for 2 years), Career Development Awards (3 awards, up to $75,000 a year for 3 years), Resident Research Awards (13 awards for $15,000 for 1 year), and Institutional Educational Awards (9 awards for $50,000 a year, annually renewable for up to 5 years). Additionally, the OREF supported other research and educational programs, and special lectureships. Recently, the OREF has begun to place a portion of each year's donation into an endowment to provide an additional source of support in the coming years. Justifiably, the orthopedic surgeons take great pride in this highly successful program.

The Wisconsin Alumni Research Foundation

An outstanding example of a successful research program associated with an academic medical center is the Wisconsin Alumni Research Foundation.[14] This program resulted from a lesson learned by a distinguished scientist at the University of Wisconsin. In the early 1900s, Professor Stephen Moulton Babcock in the Department of Agricultural Chemistry devised a method for testing the content of butterfat in milk.[15] He did not patent the process, but released it for commercialization for the public good. He soon found that once the method was made public, he had no control over the standardization of the process. Moreover, his discovery proved to be highly lucrative, but none of the potential royalties were recognized by the inventor, the School of Agriculture, or the University of Wisconsin. In 1924, Professor Harry Steenbock discovered that Vitamin D was manufactured and stored in foodstuffs that had been exposed to ultraviolet irradiation. Steenbock found that this process provided a mechanism for delivering a highly potent antirachitic factor to laboratory animals, and he realized that his experimental results were immediately applicable to humans as a preventive medicinal agent for rickets.[16] The Board of Regents of the University of Wisconsin declined his offer to have them apply for patents to the discovery. Therefore, Steenbock and his colleagues, with the help of selected alumni at the University of Wisconsin, set up the Wisconsin Alumni Research Foundation (WARF), which was administered and regulated by an agency identified with, but separated from, the University of Wisconsin. The principal objectives of WARF were to seek patent rights to protect discoveries by the faculty and to develop licensing arrangements with private companies who would market the discovery for the public good. Proceeds of the royalties would go to the investigator, to the investigator's department, and to WARF to support certain academic needs of the faculty. Dr. Steenbock's discovery proved to be highly successful, both as a significant advance in preventive medicine and as a source of endowment and usable revenue for WARF.

Twenty years later, Professor Karl Paul Link in the Department of Biochemistry at the University of Wisconsin discovered dicoumarin.[17] Several similar compounds subsequently were synthesized, among them dicumoral, the first oral anticoagulant, and warfarin (a word derived from WARF and the "arin" of coum*arin*), a highly effective rodenticide useful in pest control. The concept of WARF was widely adapted by the faculty at the University of Wisconsin, and royalties from many additional important scientific discoveries further increased the endowment of WARF (Table 9). The substantial income generated annually by WARF primarily comes from investments but also from new inventions that have produced royalties, and from gifts, donations, and bequests. This unique university resource has provided funding for undergraduate students, graduate students, fellows, and faculty at the University of Wisconsin (Table 10) and serves as a model of how university academicians can take advantage of their discoveries for the benefit of the public, their academic departments, and the university. Subsequent to the success of WARF, similar programs were set up at the Massachusetts Institute of Technology, the California Institute of Technology, and Cornell University. Currently, such arrangements within universities are common and most have a defined administrative structure that manages relations with the industrial sector.

Academe and Industry

Fifty years ago, the industrial sector accounted for very little of the research budgets of academic universities. At that time, there was a cultural and ideologic distance between the academicians (who often made important laboratory discoveries with great potential for the public good) and industry (that depended on such new discoveries for market growth and productivity of their business). This changed in the mid 1970s when investigators at the University of California, San Francisco, and Stanford University discovered recombinant DNA technology.[25] This discovery led to the development of Genentech, the first of numerous biotechnology companies whose primary function was to develop a new generation of therapeutic agents and bring them to market. Subsequent legislation such as the 1980 Patents and Trademarks Law Amendments[26] and the 1986 Federal Technology Transfer Act[27] provided the legal structure for enhancing the collaborative relationships between academic institutions and industry.

During the last two decades, there has been increasing interaction between academic institutions and the biotechnology sector. This has resulted in an increase in the number of patents administered to universities in the United States and to a larger number of alliances between universities and industry. Support from the industrial sector for health research and development has increased from 42% of total national support in 1986 to 50% in 1993 (Fig. 12).[28] During this same period, support from the NIH decreased from 34% to 32%.

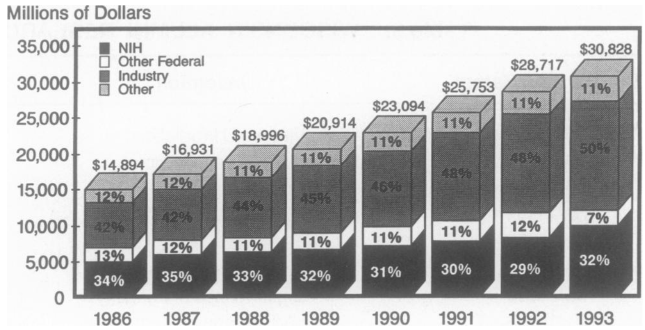

Figure 12. National support for health research and development by source, 1986-1993. Source: *NIH Data Book, 1993* (Washington, DC: DHHS, 1993).

Surgical investigators and Departments of Surgery have underused this excellent source of interaction and support, particularly in the areas of technological development, device utilization, materials testing, and outcomes research. Surgeons will have to be more aggressive in pursuing mutually beneficial relationships with industry as standard sources of support decrease.

The Department Chairman

The Department Chairman, with his control of space, resources, and power of appointment, plays a critical role in the development of the surgical scientist. If the depart-

Table 10. WISCONSIN ALUMNI RESEARCH FOUNDATION

Projects Awarded	Total Grants (1929-1995)	Annual Grants Approved	
		Year	Amount
General research grants	$258,174,000	1963-1964	$ 1,900,000
Buildings, land, major equipment incentives	52,000,000	1973-1974	4,300,000
Faculty enhancement funds	5,000,000	1983-1984	7,600,000
Donor-directed gifts	12,385,000	1984-1985	9,000,000
Special research funds	4,893,000	1985-1986	10,000,000
Reserve fund income	8,011,000	1986-1987	13,400,000
Beers and Murphy Clinical Nutrition Center	1,800,000	1987-1988	12,200,000
		1988-1989	13,400,000
Total	$342,263,000	1989-1990	14,200,000
		1990-1991	15,800,000
		1991-1992	16,000,000
		1992-1993	18,200,000
		1993-1994	21,616,175
		1994-1995	24,240,000

ment chair is committed to the development of excellent programs in surgical research and to supporting the development of house staff and junior faculty members, not only will the young surgical scientist mature as an investigator and as an academician, but the Department of Surgery and the field of surgery will benefit from his efforts. The matter of commitment has an important quantitative component that relates not only to the actual provision of resources and the creation of a stimulating and productive research environment, but to the assurance of strong moral support and encouragement to aspiring surgical scientists as they work their way through the early phase of development.

The potential pitfalls faced by the young investigator were perhaps best portrayed by Carl Dragstedt, a pharmacologist at the University of Chicago,[29] and the brother of the late Lester Dragstedt, the first winner of the American Surgical Association Medallion for Scientific Achievement. He described a young house officer, Cockrell Robinson, better known as "Cock Robin," who as a postdoctoral fellow made an important discovery. After his published report of this observation, several things started to happen to him. He was appointed to the editorial board of a prestigious medical journal. He was asked to join a study section at the NIH. Because of his own highly cited publications and the notoriety gained from his frequent speaking engagements as a visiting professor at academic institutions both in the United States and abroad, the dean took notice of his accomplishments. He was promoted to associate professor and given tenure. He was assigned to assorted academic responsibilities, such as the chair of the curriculum committee and membership on the admission's committee. His wife moved the family to a new house that was beyond their means and their needs.

Gradually, Robin's interest in the laboratory waned as he found his research work and scholarly pursuits crowded out by a burdensome administrative load. It was not that he assumed these administrative duties with reluctance; he actually enjoyed some of them and found prestige associated with many of his responsibilities. However, he was soon torn between the extracurricular duties and his desire to be a creditable investigator. In the end, he made the fatal mistake of dividing his time and energy between too many tasks. He predictability became ineffectual in each of them, and with time, he met a quiet academic death. Unfortunately, Robin's story is not unique, and we can find many examples of such failed expectations in the field of surgery.

Why do we have situations like Cock Robin, and why do so many of our brightest and talented young surgical scientists fail to progress beyond their formative years of preparation for a career in clinical research? Rarely, a gifted young faculty member can shoulder the substantial burdens placed on them by well-meaning Department Chairmen and administrators in the university. However, most cannot, and it is the duty of the Department Chairman to protect them. It is important that our rich resource of young talent be encouraged and given every opportunity to mature into accomplished surgical scientists. Specific steps should be taken to ensure that they are successful.

Opportunities in laboratory investigation should be provided only to house officers who are committed to a career in clinical research. The research laboratory should be structured and equipped adequately. A mentor must be present in the laboratory to guide and teach the house officer, to oversee every aspect of his training, and to provide the intellectual stimulation and the rigorous scientific discipline during the young investigator's formative stage of development.

House officers and junior faculty members who decide to enter the laboratory must have protected time. This is easier to do for the house officer than for the faculty member who is eager to establish his surgical practice. The guidelines regarding the protected time should be stated clearly and agreed to by both the laboratory investigator and the Chair of the Department. Generally, the success of the laboratory experience is related directly to the amount of time that the young investigator spends there.

There needs to be a more efficient system of postgraduate specialty education, both in general surgery and the surgical specialties. Currently, it takes 5 years of clinical surgery to complete a residency in general surgery. There are ways in which the American Board of Surgery and other specialty boards, which require an initial period of education in general surgery before specialty training, could jointly design residency programs that are shorter than the current requirements, and yet provide the necessary clinical experience for the general surgeon and the specialty surgeon. There have been many attempts to merge residency requirements and shorten the length of clinical training; however, few have been successful. If the concerned boards would focus on only what is best for the residents' education, it should be possible to improve the current training programs while making them shorter.

In closing, I would say that it is critical to our specialty that we maintain a rigorous commitment to surgical investigation. I believe that it would be hard to prevent surgeons from being scientists no matter what the restrictions or the adversities. Where there is a sick surgical patient and a surgeon with an inquisitive mind, there will be a study and a significant observation leading to improved care for the patient. As members of the American Surgical Association, we must not be detracted from the duality of our mission as clinicians and investigators. With the current forces at play, there is a risk that we will be relegated to the position of "proceduralists." If we accept this assignment, we will be like airplane pilots, performing a task from point A to point B, with little involvement in the study of how to improve the aircraft, how to make it safer, or how to operate it in a cost-efficient manner. The specialty of surgery always has played a leadership role in furthering the field of medicine, and if we are to continue to do so, we must accept the challenges that the rapidly evolving advances in science will bring us. If successful, we will continue in the leadership role that has been characteristic of the members of our profession and this Association.

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