With aging of the US population and continued success in prolonging survival of patients with cardiovascular disease, the prevalence of cardiovascular disease will increase exponentially in the next several decades.1 The anticipated disease, the prevalence of cardiovascular disease will increase as successful as possible.

Cardiovascular medicine and to make the initial career stages will need to make informed choices about entering academic considerations for international trainees are included. Our aim is to provide new investigators with many of the tools they need to get started in research; writing a grant; publishing a paper; finding a job; launching a successful research career in cardiovascular medicine across the spectrum of cardiovascular specialties and across the strata of scientific investigation. The primer will provide advice for choosing a mentor; selecting a research project; identifying funding opportunities; selecting a research career pathway among the many opportunities in basic, clinical, epidemiologic, outcomes, and translational research; writing a grant; publishing a paper; finding a job; and making the transition from fellow to faculty. In addition, issues on ethics in cardiovascular research and specific risk factors, including hypertension, tobacco consumption, high body mass index, physical inactivity, diabetes mellitus, and the metabolic syndrome. Moreover, a worldwide epidemic is developing in the context of socioeconomic changes that have led to increases in body weight, blood sugar levels, lipid levels, and cigarette smoking. As a result, the global prevalence of cardiovascular disease and cardiovascular mortality is increasing rapidly.

The current state of affairs provides a tremendous opportunity for young investigators. Clearly, more unmet research needs exist in cardiovascular medicine than ever before. Across the world, the future of cardiovascular medicine lies in promoting health in addition to developing better therapies to treat disease. Although we have been successful in preventing some forms of cardiovascular disease such as rheumatic heart disease and have made improvements in the management of some cardiovascular risk factors, much work is left to be done as increases in the prevalence and severity of other risk factors have kept the overall risk of cardiovascular disease unchanged over the last 2 decades. Within the next 50 years, we will reach a point when the impact of prevalent cardiovascular disease can no longer be reduced, with disease prevention becoming our primary goal. A global perspective is essential to ensure that our collective resources are dedicated to preserving health for the greatest possible number of people. In addition to continuing our strong commitment to basic and clinical research, an emphasis on translational research will be vital in meeting the needs of our patients. Translational research entails not only translational research...
The Cardiology Workforce

In the early 1990s, the number of subspecialty training positions in the United States was reduced to help quell an anticipated surplus of subspecialists by the year 2000. Caps in the number of Medicare-supported cardiology fellowship positions and widespread expectations of a surplus in cardiovascular specialists effectively reduced the number of fellowship positions by 12% between 1995 and 2001. Reversing these caps would undoubtedly be met with many political and economic obstacles, and without alternative sources of funding for additional fellowship positions, this option is unlikely to come to fruition. The imperfect vision of the 1990s has resulted in a current and future shortage of cardiologists. In addition, recent world events and changes in immigration laws threaten to reduce the number of international medical graduates, who make up a significant proportion of cardiologists in the United States. The decreasing supply of cardiologists and the increasing clinical demand have led to an even greater shortage of academic cardiologists. The challenge we currently face is to meet clinical demands while promoting cardiologists’ academic pursuits.

Shortening the training period in cardiovascular medicine constitutes a viable option for expanding the cardiovascular workforce. Currently, the minimum postgraduate training period required to become a cardiologist is 6 years: 3 years of internal medicine residency followed by 3 years of cardiology fellowship training. A streamlined training program would lessen clinical commitments for those motivated to enter the academic arena in which additional training and experience in research methodologies are often warranted. Additionally, shortening the training period would mobilize trainees into the workforce more expeditiously and would help in recruiting applicants to cardiology. The American Board of Internal Medicine and the American College of Cardiology are currently working to reduce training in cardiovascular medicine by 1 year. Specifically, training in internal medicine would be reduced to 2 years, followed by a hybrid year focused on cardiovascular preventive care and finally 2 years of training in clinical cardiology. This approach limits research exposure during the training period but frees a year for dedicated research training for those who are interested.

Expanding the pool of cardiovascular healthcare providers beyond cardiologists is another solution to the growing demand for cardiac care. Family practitioners and general internists have been incorporated into cardiovascular care settings to complement the specialized care provided by cardiologists. In addition, the integration of nonphysician providers, including nurse practitioners and physician assistants, into cardiovascular healthcare teams in both inpatient and outpatient settings has led to an improvement in productivity and patient outcomes. Care by internists and nonphysician providers may relieve some of the clinical demands placed on cardiologists, allowing them to pursue academic endeavors more effectively.

Regardless of the solution, one thing is clear: We need more cardiologists. Fortunately for young trainees, a career in cardiology, whether private or academic, will provide numerous opportunities and job security. In 2002, 40% of hospitals with >100 beds were attempting to recruit cardiologists, many with difficulty. As the baby boom generation continues to age, the adjusted shortage of cardiologists is expected to continue until at least 2040.

Debt Burden

The foundation of the physician-scientist career is based on 1 of 2 possible training paths: enrolling in the medical-scientist training program or, more commonly, adopting an academic trajectory after entering medical school. Those in a medical-scientist training program, who receive a combined MD/PhD degree, frequently complete their training with limited debt burden. In contrast, the larger number in the other career path, the so-called “late bloomers,” amass incredible debt financing their education. For those graduating from medical school in 2004, students in private schools graduated with a median debt of more than $130 000 and those in public schools with a median debt of $100 000. On completing medical school, graduates entering clinical arenas are required to obtain additional training during which they receive a relatively low income. Unsubsidized loans will accrue interest during this period. Physicians who subsequently lengthen their training by entering subspecialty training programs such as cardiology or who pursue further training in research methodologies do so with significant opportunity costs by accepting wages that are frequently less than a third of those that they would receive in practice. All the while, loans continue to grow. Faced with such debt, it is no wonder that many physicians flock to higher-paying job opportunities in clinical practice on completing their training instead of the lower-paying academic positions.

In an effort to encourage increased participation in clinical research and to help combat debt for academic physicians, the
NIH initiated 4 loan repayment programs for individuals involved in clinical research, pediatric research, and health disparities research and for individuals from disadvantaged backgrounds.28,29,32 These programs were created in addition to the older loan repayment program for individuals conducting research in infertility and contraception. Applicants in these categories who possess educational debt exceeding 20% of their annual salary can receive up to $35 000 per year of tax-free debt relief in exchange for a 2-year research commitment during which they conduct 20 hours of research per week.

Research Funding
Between 1998 and 2003, the NIH budget doubled thanks to visionary congressional leadership. The number of applications submitted for new grants and grant renewals remained flat during this same period33; consequently, researchers enjoyed tremendous resources. The situation has changed significantly in recent years. The initial opportunities created by the expanded NIH budget have been transformed into major budgetary challenges. The doubling of NIH research funding stimulated significant growth in research infrastructure and workforce.34 However, since 2004, the percent growth of NIH funds has decreased significantly, and in 2007, the NIH budget actually declined by 3.8% (corrected for inflation) from 2006.35 The NIH budget has been outpaced by inflation, the growing cost of new, more complex areas of research, and the increasing demand triggered by the period of prosperity (Figure 2).34 Compounding these financial difficulties is the significant shift of funds and political emphasis to biodefense; funding for biomedical science has suffered.

The number of new investigators being funded by the NIH has remained relatively stable since 1980 despite the dramatic increase in the NIH budget over this time period and an increasing volume of applications (Figure 2).36 Additionally, the number of grants being awarded from the NIH to established investigators >50 years of age is steadily increasing, and awards to those ≤35 years old of age are decreasing, falling from 23% of all NIH awards in 1980 to just 4% in 2000 (Figure 3).19,33,15,37 In fact, the chances of receiving...
funding for one’s first NIH grant application has dropped from 21% in 1998 to only 8% in 2006.38 Exacerbating the strain on young investigators is the financial status of academic medical centers. With declining reimbursement for patient care, academic physicians are facing intense pressure to increase their clinical volume to generate revenues for their institutions. With decreased research funding, a young investigator loses “protected” research time and consequently becomes less competitive on subsequent grant applications.8 This cycle justifiably appears daunting to young physicians entering the workforce, often encouraging them to select careers in private practice. Fortunately, however, the trends are improving.

The NIH has adopted various mechanisms such as differential pay line considerations to ensure that new applicants are not disproportionately affected by decreasing budgets. Additionally, the review process for grants is now expedited, and the Pathway to Independence award program was initiated in 2006. This program seeks to fund postdoctoral candidates for 2 years of mentored research followed by 3 years of R01-level funding, thereby bridging participants into tenure-track academic positions.34 The NIH budget has fluctuated significantly during its history as political and economic factors have taken their toll (Figure 4).35 We are currently in a period of decline, but it is only a matter of time until NIH funding rises. In addition to NIH initiatives, private, not-for-profit research funding has increased dramatically over the last few years. For example, the American Heart Association contributed more than $145 million in 2005 to 2006 alone to cardiovascular research.39 With a renewed focus on young investigators, programs such as the AHA Fellow-to-Faculty Transition Award provide support for mentored research for up to 5 years spanning the completion of fellowship training through the early years of the first faculty appointment. Additionally, tremendous investment by philanthropic foundations, a funding source relatively unique to the United States, provides approximately $20 billion a year for research. As opposed to the NIH, these funding sources are continuing to grow. From 1994 to 2003, private, not-for-profit research funding increased by 36%, and industry support more than doubled over the same period (Figure 5).40 In fact, industry has been funding more research than the NIH for >10 years. In 2005, industry spent $51.3 billion on research, 78% more than the NIH that year.25

The academic community is beginning to recognize the importance of marketing the many benefits of medical research to the public and to legislators. We are currently failing at this task. In a recent survey, 73% of Americans could not name the NIH as the government body that funds most medical research.41 Additionally, few could conceive of the dramatic financial impact that medical research plays. A report by the Albert and Mary Lasker Foundation, summarizing the independent findings of 9 distinguished economists, documents that the “extended healthy lives” of Americans are due in great part to advances in medical research.42,43 Although these advances consume $45 billion annually, the return on this investment is staggering. The work of the 9 economists estimated that increases in life expectancy in the United States between 1970 and 1990 were worth roughly $2.8 trillion each year.42–44 This represents a rate of return on research investment of >100 to 1. Evaluating the return on cardiovascular research funded by the NIH in particular, the total investment over the last 30 years is approximately $4 per American per year. This investment resulted in a 63% decrease in

Figure 4. Annualized growth of the NIH budget. Annualized NIH budget growth rates have fluctuated greatly since 1970. The growth rates shown have been adjusted for inflation. From Loscalzo J. The NIH budget and the future of biomedical research. N Engl J Med. 2006;354:1665–1667. Copyright © 2006 Massachusetts Medical Society. All rights reserved.

![Figure 4](image-url)

Figure 5. Funding for biomedical research by source, 1994 to 2003. Funding from all sources for biomedical research has grown steadily since 1994. However, non-government funding is increasing at a faster rate than government funding, with biomedical industry now providing the majority of research funds. From Moses H III et al. Financial anatomy of biomedical research. JAMA. 2005;294:1333–1342. Copyright © 2005 (JAMA) American Medical Association. All rights reserved.
Characteristics of an Investigator

We provide this advice to the current and future generations of cardiovascular specialists considering careers in academic medicine. To be successful, you must be realistic and know yourself. Determine your skills and talents, and do not fool yourself or anyone else into believing that you are good at something when you are not. Research careers are rewarding but difficult, and they require hard work, motivation, and passion. Investment in work that is propelled by your aptitude and passion will be rewarded, whereas investment in something for which you have little talent will lead you through a series of Sisyphean tasks that are ultimately too costly to sustain.

Once you have identified your talents and interests, attaining supplemental skill sets is essential for a productive academic career. For the basic scientist, the postdoctoral fellowship is a well-established key to success. A training experience in clinical research is no less important. Formal training programs in epidemiology, biostatistics, and clinical research methodologies are valuable to trainees interested in pursuing careers in clinical research.

In addition to specific skills, certain personal characteristics facilitate a successful academic career. Creativity is indispensable. The creative individual, or innovator, is able to generate new ideas and to build on previous research findings in truly novel ways. However, to capitalize on this talent, one must be willing to take risks. All research involves some degree of risk in that one never knows whether an experiment or analysis will work before performing it. One strategy to minimize risk wisely while continuing to pursue creative theories is to develop research projects possessing various levels of risk. For example, adopting a risky project that is truly novel and a safer project that is based on a more established body of data or is likely to yield results regardless of the outcome guarantees some progress and accomplishment.

Additionally, in the current era as science becomes more complex, a successful investigator must be able and willing to work as part of a team. In academic medicine, the model of the isolated scientific prodigy or solitary investigator who makes it alone is obsolete. The investigator must be able to communicate effectively and collaborate within a team that has mutual confidence in one another. Consistency and diligence are vital to academic medicine as they are in any competitive field. And although confidence is essential, you must also have equanimity and an evenness of mind and disposition; otherwise, biases develop that can cloud your judgment in interpreting and planning further investigations. Resilience and perseverance are necessary to survive the inevitable fluctuations in research funding and support. You must accept these fluctuations and move on. Finally, altruism is crucial. The motivation for an academic career must be rooted in the desire to help humanity and further the field of medicine, as well as personal fulfillment. Without altruism, investigators frequently focus on the importance of their own accomplishment and not on the advancement of science. This mind set may lead to the hoarding of data to ensure that you are first to report a finding and thus may delay the dissemination of data that may help other researchers and, more important, advance the field toward improved human health.

Mentorship

Selecting a mentor is absolutely critical to career development and requires initiative and practicality. The process of identifying potential mentors should begin as early as possible and should be factored into the selection of a cardiology fellowship program. Mentors and program directors at the residency level should guide trainees to cardiovascular training programs that will foster their research interests and talents. The young investigator must pursue mentors by reading their articles and setting up interviews. It is often helpful to obtain >1 mentor: a general career mentor and 1 specific research mentors. Although the presence of a senior mentor who may be able to provide significant insight into the field and its future can have its advantages, younger investigators with substantive research enterprises of their own may be more accessible and better able to provide assistance with the practical issues of the early stages of a scientific career. You should look for someone whom you respect, who is accessible to you, and who is in a position to assess and act in your best interest. Your mentor should have an established research repertoire that ideally matches your interests. Keep in mind that your early research efforts will be tightly linked to the mentor’s projects.

Academic Career Models

Once you determine who you are and discover your assets, you must decide what career path you want to follow. Do you want to be a pure investigator, a clinician who does research, an educator, or a combination of these? In terms of a research career, whether in basic, clinical, translational, epidemiological, or outcomes research, several models are available. A physician-scientist spends most of his or her time conducting laboratory research with clinical relevance. Advanced research training is required (with or without a combined MD/PhD degree). This faculty track is possibly the most endangered in major medical centers today. A translational scientist performs clinically oriented research (from molecules to outcomes) as part of a research team. The translational scientist bridges the work of the physician-scientist and the professional clinical investigator, applying knowledge to appropriate patients or populations. Advanced research train-
ing is required. A professional clinical investigator spends most of his or her time conducting clinical trials, outcomes research, or epidemiology. An advanced degree such as a PhD or a master’s degree in public health or clinical investigation is often required. A clinical investigator is involved in patient care and participates in research as a team player with a professional clinical investigator. No special advanced training is required. Whatever path you follow, you will need a mentor and an institution that will train you to work as part of a research collaborative.

Integrating research, clinical activities, and teaching is a major concern for trainees. It is important to realize the remarkable time commitment required to juggle the 3 responsibilities but that an academic career does not necessitate that you do so. Many successful academicians have chosen to focus on 1 or 2 of these academic pursuits. However, 1 approach to success in all 3 arenas is to focus your research and clinical expertise in 1 particular area and to work within a research team. A team of investigators can succeed in completing a comprehensive research goal, whereas the individual investigator focuses on a specific aspect of the project and thus develops significant expertise while limiting the research time commitment. Although serving as an educator will not support your research career directly and usually provides no salary support, teaching is a noble vocation that is essential to the future of the field and can reinforce and supplement both your research and your clinical activities. The balance between professional life and family life is an additional concern that often influences trainee career choices but can be established through focus, careful planning, and appropriate institutional support.

Conclusions

Cardiovascular medicine has a rich research heritage, and the growing global burden of disease in the decades to come will present ever-greater research opportunities across the full spectrum of research and in every of cardiovascular subspecialty. Young cardiologists with the drive to pursue an academic career should be encouraged, not discouraged, by the looming shortage of academic cardiologists, as well as the increasing mechanisms of financial support such as loan repayment programs and expanded funding from the private sector. Early career investigators also can look forward to an era of increasing research collaboration. Despite the perceived challenges, careers in academic cardiovascular medicine have great personal and professional rewards and the potential to contribute importantly to reducing the financial, societal, and human toll of cardiovascular disease.

Disclosures

None.

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**Key Words**: training ■ health occupations ■ mentors ■ research personnel
Academic Careers in Cardiovascular Medicine
Valentin Fuster, Sarina van der Zee, Sammy Elmariah and Robert O. Bonow

Circulation. 2009;119:754-760
doi: 10.1161/CIRCULATIONAHA.108.792564

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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