

# NATIONAL HEART, LUNG, AND BLOOD INSTITUTE

## Research Training and Career Development

human resources for research in  
the 21st century

..... report of a November 1999 workshop .....

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# NHLBI Research Training and Career Development

*human resources for research in the 21st century*

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## Foreword

As we enter a period of great challenges and excitement in the life sciences, in which scientific knowledge is changing and accruing at a fast pace, extraordinary opportunities present themselves for making substantial progress in all aspects of biomedical science. New areas of study, such as functional genomics, tissue engineering, and bioinformatics, among many others, are being pursued with increasingly powerful techniques and instruments. The need to translate these multidisciplinary efforts to the clinical setting is becoming increasingly urgent. New strategies and competencies are required by modern investigators to fully exploit this situation, leading inevitably to the conclusion that major changes in recruiting, educating, training, retraining, and retaining the future scientific workforce will be necessary.

With these imperatives in mind, the National Heart, Lung, and Blood Institute undertook a review of its current training and career development programs, and convened a meeting of experts on November 2-3, 1999, to consider all aspects of this important area. From the deliberations of this workshop, a number of significant recommendations emerged; some may lie beyond the scope of the Institute, but many reside well within its mandate and mission. The proceedings of the workshop and the recommendations developed from it are presented here, and we are grateful to all who participated. These deliberations will be of great use to the Institute and its constituency in developing the human resources capable of meeting the challenges of modern biomedical research, set against the rich diversity and rapidly changing demographics of American society.

Claude Lenfant, M.D.  
Director



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## Executive Summary

The rapid pace of scientific progress and the challenges facing academic medical centers have raised concerns about the ability of National Heart, Lung, and Blood Institute (NHLBI) training programs, as currently structured, to produce the scientific workforce needed for the future of heart, lung, blood, and sleep disorders research. An internal review of NHLBI training programs identified several issues needing to be addressed, including developing new investigators with the necessary competencies and breadth of expertise needed for the future of biomedical research, recruiting and retaining such investigators in the scientific workforce and ensuring adequate representation of the nation's diversity in that workforce, and providing a continued flow of qualified physician-scientists able to translate findings freely between the basic and clinical realms.

Workshop participants considered the current major emerging scientific developments in research on heart, blood vessel, lung, blood, and sleep diseases and disorders and blood resources and, in light of them, recommended actions enabling the NHLBI's scientific and professional training programs to match evolving research opportunities. Participants addressed six issues:

- # What are the scientific and professional competencies that will come to predominate at the beginning of the new millennium, and how will these be introduced into training programs?
- # What should be the balance between a broad education with a global perspective, and specific, focused training in sophisticated technology and methodology?
- # What measures are necessary to recruit and retain the best minds in the pursuit of research in heart, lung, and blood diseases and sleep disorders?
- # What are the best approaches to mentorship in a multidisciplinary training environment and how should they be evaluated?
- # How can we develop a research workforce of the highest scientific quality based on our nation's diversity?
- # How can we supply a cadre of physician-scientists capable of rapidly bringing new information to the bedside?

A systematic review of the NHLBI's currently available training programs demonstrated a less-than-optimal representation in areas crucial to biomedical research in the coming decades, such as informatics, statistics, functional genomics, computational science, and integrated physiology. The need to encourage and support young investigators to enter basic and clinical biomedical research was widely recognized. Participants also noted that the structure of training programs has changed little since 1975, though they recognized the new clinical research career development awards (K23, K24, K30) to be a notable exception. They expressed concerns that some training programs may treat trainees as a highly-qualified and inexpensive work force. In addition, the independent career investigators eventually produced may be too narrowly focused and lacking in breadth of vision and flexibility.

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Existing national research training programs of the National Institutes of Health (NIH) Intramural Program, the National Human Genome Research Institute, the National Science Foundation, and the Howard Hughes Medical Institute were reviewed for their particular applications to NHLBI programs. Workshop participants agreed that these programs provide useful models of multidisciplinary research training with increased flexibility, incentives, and emphasis on emerging scientific competencies, workforce diversity, and use of information technology.

## **A. Scientific Competencies for the 21st Century**

Participants recognized the immediate need for such well-defined competencies as bioinformatics and use of DNA array technology, and the need to integrate several disciplines into common, multi-faceted approaches to biomedical problems. Early training in information technology, development of computational expertise, and exposure to a broad array of scientific disciplines will be needed to provide an educational background that is both broad and deep enough to provide adequate preparation for successful future investigators. Qualified teachers and students going into the life sciences in the mathematically-based areas of bioinformatics, statistics, and computer science are needed acutely. Full realization of the potential of developing DNA array technologies will require qualified researchers capable of using the vast amounts of data produced by such approaches.

Participants felt that greater emphasis was needed on the mathematical basis of biomedical science. The NHLBI may need to establish training programs in medical informatics, to encourage new alliances between academia and industry, and to de-emphasize the present disease-specific orientation in biomedical research training. The need for adequate development of oral and written communication skills among trainees was also recognized, as was the importance of providing opportunities for retraining of mid-career investigators. Targeted financial incentives to scientists with mathematical or informatics training was recommended to attract and retain needed talent in heart, lung, blood, and sleep disorders research.

### ***Key recommendations related to scientific competencies included:***

- # Development of new courses and expansion of existing training programs to address needed new technologies and competencies.
- # Inclusion of training components in new research programs.
- # Provision of opportunities for retraining and continued education for investigators at all stages of career development.

## **B. Multidisciplinary Collaboration**

Participants recognized that the increasingly multidisciplinary nature of biomedical research mandates the development of multidisciplinary training programs, but, perhaps more importantly,

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training will be needed in the intrinsically collaborative nature of research itself. Although capitalizing on the rapid evolutions in multiple disciplines will require broadly trained investigators; no one individual can encompass all the necessary knowledge and skills. The need for collaboration to facilitate future research advances was seen by workshop participants as paramount. This will imply more teamwork and less independence on the part of investigators, whose training and reward systems must be redesigned accordingly.

Participants identified innovation and collaboration as two principal ingredients of a successful research program for the 21st century, and identified research networks as having considerable potential to facilitate multidisciplinary training. Increased contact among investigators and trainees and different institutions is needed and can be facilitated by continued advances in communications and information technology. Current support mechanisms need to be more flexible to meet rapidly changing needs of scientific training and the settings in which it occurs. NIH-wide support for multidisciplinary training programs should be emphasized and communicated throughout the academic community, which will likely find a way to develop them. Particular attention may be needed to revising review criteria to encourage multidisciplinary approaches without incurring undue criticisms of vagueness or lack of focus.

***Key recommendations related to multidisciplinary training included:***

- # Encouragement of broad, multidisciplinary approaches to research at all stages of training.
- # Development by the scientific community of innovative approaches to research training, emphasizing multidisciplinary approaches, networking and collaboration, and linking multiple institutions with unique expertise into “virtual” training centers.
- # Increased emphasis on multidisciplinary team approaches and reduced focus on independent R01 research support, both in academia and at the NIH, as metric for judging success.

## **C. Recruiting and Retaining Capable Investigators**

Participants recognized the declining number and potentially inadequate prior preparation of new trainees in the biomedical sciences as a major threat to the future of biomedical research. Disincentives for choosing science as a career and underappreciation of the research enterprise by society in general must be addressed if this trend is to be reversed. Qualified faculty needed to train subsequent generations of researchers are being lost to industry and promising candidates are not entering training. Increasing the trainee “pipeline” was a topic of great concern. The need to convince young physicians and scientists to engage in research was recognized as a major hurdle in generating the workforce needed for the future of research on heart, lung, and blood diseases and sleep disorders.

Consensus was not reached on the roles of the NHLBI and the NIH in attracting primary and secondary school students to scientific careers though there was general agreement that such efforts were needed. Practical aspects of recruiting and retaining trainees were discussed at



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length, including adequacy of stipend and research support levels, the possibility of debt forgiveness, and the need to bridge the gap between career development (K series) and independent (R01) awards. The biomedical industry was recognized as an important and under-utilized potential partner in the support and provision of research training, and one that should be encouraged to contribute more actively to research training programs.

***Key recommendations related to recruiting and retaining capable researchers included:***

- # Development of programs to attract capable students to scientific careers early in their career decision-making process.
- # Enhanced financial support, including stipends and debt reduction, for trainees entering areas of critical shortages.
- # Improved dissemination of information about NHLBI training programs, and about the value and importance of biomedical research in general.
- # Development of partnerships with industry (a major beneficiary of NIH-sponsored programs) in funding training programs.

## **D. Mentorship**

The importance of good mentorship and the many current threats to its practice emerged as a major theme throughout the discussions. Participants recognized that the role of the mentor is frequently ill-defined and that it may receive inadequate emphasis during review of training, fellowship, and career development grant applications, but that it is crucial at all steps in a trainee's career development.

Participants felt a distinction could and should be made between "local" mentoring in the traditional one-on-one, apprentice-type relationship, and "global" mentoring by a team engaged in interactive multidisciplinary science. The need for training in mentoring skills was recognized, as was the importance of assuring adequate attention to mentorship plans in reviews of training and career development award applications. Participants felt that funds to support mentoring were critically needed, and that mentors should expect support by their institutions in all aspects of a trainee's development. "Training" programs that treat trainees primarily as ready sources of skilled labor should be identified and their program directors obliged to meet their training responsibilities or face loss of training support.

***Key recommendations related to mentorship included:***

- # Development of materials and programs for training in mentorship.
- # Encouragement of team approaches to mentorship to enhance the multidisciplinary nature of training.
- # Provision of adequate support for mentors' efforts.

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- # Increased emphasis on evaluation of mentorship plans in training and career development award applications.

## **E. Diversity in the Workforce**

Workshop participants recognized the importance, and the challenges, of ensuring that the research workforce of the future reflects the cultural and ethnic diversity of the American population. There is a critical need to interest young people of racial/ethnic minorities in biomedical research as early in their educations as possible. The shortage of mentors and successful role models who are themselves members of racial/ethnic minority groups is a major problem in this regard. A possible solution may be development of networks of dedicated faculty willing to mentor minority students.

Review of programs successful in attracting minority trainees to biomedical research identified the importance of scholarship support, bridging programs from secondary school, close involvement of parents, and small group and tutoring programs throughout the college years. The combination of a pre-freshman summer transition program, special tutoring and help in decision-making, and group study, may be critical in making such programs work. Participants agreed that a major goal of future research programs must be to ensure that the composition of the community of biomedical investigators truly reflects the cultural and ethnic diversity of the nation.

### ***Key recommendations related to workforce diversity included:***

- # Development of a Minority Scientist Mentorship Network among scientists with research expertise and experience who are dedicated to the ideal of diversity in the workforce.
- # Targeted programs to address financial pressures and other obstacles faced disproportionately by minority trainees.
- # Development of programs to support general research infrastructure, training programs, etc., at minority institutions in scientific fields of particular need.

## **F. The Special Case of Clinical Research**

Participants expressed uniform concern that the clinical investigator, uniquely positioned to translate basic research advances to the clinical arena, is seriously endangered. Major deterrents to physicians' choosing research careers include debt burdens, low training stipend levels, uncertainties of stable support throughout a research career, and difficulties in protecting adequate time for research for junior clinical faculty. The need to encourage and support young scientists to enter basic and clinical biomedical research was recognized as a critical issue. Strengthening and extending M.D.-Ph.D. programs, and facilitating pursuit of a Ph.D. degree at the end of clinical training, were also identified as valuable approaches. The loss of junior

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physicians to research appears most evident at the assistant professor level, where bridging mechanisms to independence may be needed.

Participants also recognized that encouragement and preparation of Ph.D.s to do clinical research are needed, such as training in the pathophysiology of human disease. Clinical research also requires an understanding of disciplines related to clinical practice, such as health services research, epidemiology, and clinical trials. Specialized training for physicians and non-physicians will enhance the capabilities of both in clinical research, and might involve advanced degree programs in biomedical science, epidemiology, and clinical trials for physicians, and in human studies for Ph.D. scientists. In all cases, a multidisciplinary approach should be encouraged.

***Key recommendations related to clinical research included:***

- # Development of programs created specifically to support training of M.D.-Ph.D. investigators.
- # Establishment of clinical training networks, possibly linked to current NHLBI-sponsored research networks and multicenter studies.
- # Provision of specialized training for physicians in research disciplines and for Ph.D. scientists in clinical disciplines.

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# WORKSHOP REPORT

## 1. Background and Need for Workshop

The genomic revolution at the end of the 1990s has brought urgency to consideration of the current state of research training. The rapid development of new approaches to diseases of the heart, lungs, and blood, together with a burgeoning overload of raw data, raises the need to ensure that research training programs not only keep pace with scientific progress but that they also fully address *future* workforce needs. The perception that training programs have not always kept pace with scientific progress, that training approaches did not capitalize on technologies for information sharing, and that training mechanisms had become too inflexible to facilitate innovative approaches and promote the growing need for multidisciplinary collaboration, led the NHLBI to re-examine its current training programs from the perspective of ensuring a qualified workforce for the future.

Review of NHLBI training programs with trainees, training program directors, outside advisors, and NHLBI staff identified several significant challenges to their future success. These include: promoting and supporting new investigators with the necessary competencies and breadth of scientific expertise needed for state-of-the-art research; recruiting and retaining such investigators in the scientific workforce and ensuring adequate representation of the nation's diversity in that workforce; and providing a continued flow of qualified physician-scientists able to translate research from bench to bedside and back again.

To address these issues, the NHLBI convened a workshop in Bethesda on November 2-3, 1999, to review the Institute's current training programs and identify changes needed in them to meet the scientific opportunities of the future.

### A. Constitution of the Workshop

Speakers (Appendix 1) were invited to address a range of relevant concerns, as shown in the agenda (Appendix 2). Several of these speakers were identified as members of an "Expert Panel" charged to meet in closed session at the end of the formal presentations, to consider all that had gone before and to develop specific recommendations for the Institute. Active grantees in training and career development, training directors, and senior scientists were invited to attend and act as discussants during the formal presentations (Appendix 3).

### B. Charge to the Expert Panel

The panel is charged to consider the current major emerging scientific developments in research on heart, blood vessel, lung, blood, and sleep diseases and disorders, and blood resources, and in light of these to develop recommendations for the NHLBI to guide scientific and professional training programs so they may match the research needs and opportunities of the 21st century.

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***Specific questions to be addressed include:***

- # What are the scientific and professional competencies that will come to predominate at the beginning of the new millennium, and how will these be introduced into training programs?
- # What should be the balance between a broad education with a global perspective, and specific focused training in sophisticated technology and methodology?
- # What measures are necessary to recruit and retain the best minds in the pursuit of research in heart, lung, and blood diseases?
- # What are the best approaches to mentorship in a multidisciplinary training environment and how should they be evaluated?
- # How can we develop a research workforce of the highest scientific quality based on our nation's diversity?
- # How can we supply a cadre of physician/scientists capable of rapidly bringing new information to the bedside?

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## 2. Review of Currently Available Training Programs

### A. NHLBI Training Programs

Some fifteen different awards are currently offered, each with its own requirements, policy, and intent (Appendix 4). These can be grouped into three major categories:

Training grants (T series)

Fellowships (F series)

Career development awards (K series)

In October 1999, Program Directors of the T32 Institutional National Research Service Awards (NRSA) and members of NHLBI scientific staff were asked to review the scientific areas represented by current trainees, fellows, and career awardees of the Institute. A limited set of categories was provided (Appendix 5) and these were used to perform the review. For example, if a trainee was engaged in work in developmental biology, this would be recorded under category **1. Biology**; likewise, a fellow engaged in research on gene therapy would be classified in category **7. Genetics**, and so on.

The data (Appendix 6) show distributions of scientific areas for a large group of NHLBI trainees (n=1,033) and similar distributions for all F and K awardees, plotted by extramural division; i.e., the Divisions of Heart and Vascular Diseases and Epidemiology and Clinical Applications (DHVD and DECA, n=343), the Division of Lung Diseases (DLD, n=195), and the Division of Blood Diseases and Resources (DBDR, n=102). It should be noted that DECA supports only population-based and clinical studies for all the categorical extramural programs of the Institute, and has a consequently more limited training program focused on nutrition and behavioral research and epidemiology, reflecting the human subjects basis of its research portfolio.

Workshop participants agreed that this review of current NHLBI training programs indicates, despite a broad coverage of scientific disciplines, a less-than-optimal representation in areas crucial to biomedical research in the coming decades, such as informatics, statistics, functional genomics, computational science, and integrated physiology.

### B. Challenges Presented by Current NHLBI Training Programs

The structure of training programs has changed little since 1975, though the development of new clinical research career development awards (K23, K24, K30) is a notable exception. Concerns were expressed that training programs within and outside the purview of the NHLBI may keep trainees in a state of uncompleted development for more years than are really necessary and may have the effect of producing untoward debt and continuing stringency in personal resources.

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Participants expressed concerns that some training programs show a clear tendency toward utilizing trainees as a highly-qualified and inexpensive work force. Too few trainees may finally reach the status of bona fide independent career investigators and of those who do, many are narrowly focused, lacking breadth of vision and flexibility.

### **C. Selected U.S. Research Training Programs**

Four existing national research training programs were reviewed for their potential application to NHLBI programs.

#### *The NIH Intramural Training Program*

Well-developed postdoctoral training pathways exist at the NIH for laboratory research, clinical research, and for subspecialty and fellowship training. Special appointments are also made as NRC-NIH research associates in neuroscience and biotechnology and as National Institute of General Medical Sciences (NIGMS) research associates in pharmacology. Specialized courses of instruction are web-based and a wide range of graduate courses is available on the NIH campus through the Foundation for Advanced Education in the Sciences. For its wide variety of training opportunities in the intramural laboratories of the Institutes and the Clinical Center, the NIH provides support through a number of mechanisms, and has available a loan repayment program for eligible education debts. A new grant support mechanism, the K22, has been developed to provide bridging between intramural research training and independent extramural research support.

Further details are available from:

<http://www.training.nih.gov/>

#### *The National Human Genome Research Institute*

Career development and training programs are provided to prepare individuals to utilize the information derived from the Human Genome Project, the principal product of which is a massive amount of data. A new type of scientist is needed for data management of this magnitude, and the combined expertise of mathematicians, computer scientists, engineers, physicists, and chemists will be critical. Several programs are now in place to attract such scientists to genomics. Remaining challenges include: 1) how to make the relatively inexact science of biology more attractive to those from the more exact physical sciences; 2) how to encourage departments (such as computer sciences) accustomed to hiring theoretical or conceptual scientists to become more open to applied studies; and 3) how to introduce into the graduate school curriculum appropriate mathematics-based courses. Several mechanisms of support are being utilized to help this evolution.

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Further details are available from:

[http://www.nhgri.gov/Grant\\_info/Funding/Training](http://www.nhgri.gov/Grant_info/Funding/Training)

*The National Science Foundation IGERT Program*

Integrative Graduate Education and Research Traineeships (IGERT) provide for reform of graduate education as well as student support, by encouraging innovative multidisciplinary graduate education, integrated with research projects, with diversity as a central goal. Links to industry, the national laboratories, and international organizations are encouraged. The objectives at the institutional level are to aid integration of research and education, to encourage diversity, to encourage teamwork and development of professional skills, and to foster industrial and international collaboration. For the student, IGERT provides flexibility in multidisciplinary programs, prepares for a variety of careers and international experiences, and strengthens skills in leadership, communications, and teamwork complementary to broadened goals.

Further details are available from:

<http://www.nsf.gov/home/crssprgm/igert/>

*The Howard Hughes Medical Institute*

Fellowships for training in biomedical research are available at the predoctoral, medical student, and physician postdoctoral levels. The eligible fields of research training encompass basic biological processes and disease mechanisms, with an emphasis on cell biology, genetics, immunology, neuroscience, and structural biology. Because they are awards to individuals rather than institutions, they allow flexibility to shift research emphasis. They can be moved between mentors and institutions and are designed for full-time engagement in research. New approaches are being developed to accommodate the transition to junior faculty and for M.D.-Ph.D. programs.

Further details are available from:

<http://www.hhmi.org/grants/>

Workshop participants agreed that these programs provide models of multidisciplinary research training with increased flexibility, incentives, and emphasis on emerging scientific competencies, workforce diversity, and use of information technology. The Howard Hughes program, in particular, provides an approach for encouraging development of clinical researchers.





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### 3. The Future of NHLBI Training Programs

#### A. Scientific Competencies for the 21st Century

Workshop participants recognized the immediate need for such well-defined competencies as bioinformatics, use of DNA array technology, and the need to integrate several disciplines into common, multi-faceted approaches to biomedical problems. They also recognized that the rapid pace of scientific progress will make it difficult to forecast the specific skills and competencies needed by 2010. It appears clear, however, that early training in information technology, development of computational expertise, and exposure to a broad array of scientific disciplines will be needed to provide an educational background that is both broad and deep enough to provide adequate preparation for successful future investigators.

In the mathematically-based areas of bioinformatics, statistics, and computer science, the shortage of qualified teachers and students going on to the life sciences is becoming acute. Science and technology have become increasingly complex computationally as a result of enormous recent advances in information technology and computing resources. Attractive salaries in other fields are luring needed computational expertise away from biomedical research. This situation is quickly approaching a critical point; unless qualified faculty are replaced there will be increasingly fewer individuals with the necessary expertise to train the next generation of statisticians and computer scientists.

In the functional genomics arena, the advent of DNA array technologies may open the door to a new class of investigation assessing the interaction of conventional risk factors for heart, lung, and blood diseases with the simultaneous dynamics of tens of thousands of genes. Such approaches may eventually allow individual targeting of risk reduction or treatment strategies, but full realization of such strategies is currently hampered by a shortage of qualified researchers and training programs to produce them.

To meet the challenges of the needs and opportunities of the coming decades, workshop participants felt that some restructuring and redirecting of current NHLBI training programs may be necessary. Special attention may be needed to the retaining and retraining of faculty, and a greater emphasis must be placed on the mathematical basis of biomedical science to provide a closer match between curriculum and job requirements for the research workforce. The NIH may need to establish training programs in medical informatics, to encourage new alliances between academia and industry, and to de-emphasize the present disease-specific orientation in biomedical research training.

Concern was expressed by some participants that trainees are not receiving adequate preparation in oral and written communication skills. Such skills are critical to the effective dissemination of research findings and to the transmission of their expertise to the next generation of researchers they themselves will be training.

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Fewer training programs and fewer qualified applicants are available for statistics and biostatistics programs than ten years ago. Targeted financial incentives to scientists with mathematical or informatics training might attract much needed talent to the domain of heart, lung, blood, and sleep disorders research.

Participants also felt that retraining would be essential to maintaining the ability of investigators to remain competitive. Paid sabbaticals, perhaps of 6 months' duration, and travel allowances for visits to workshops and conferences, would be useful devices to encourage retraining.

***Recommendations related to scientific competencies:***

1. Specialized intensive courses should be developed, to improve skills and awareness of new technologies and methods, such as studies based on DNA arrays.
2. Consideration should be given to utilizing existing training programs for targeting new specific areas, where feasible, by adding slots in current training grants to target under-represented areas such as quantitative applications in life sciences.
3. Current and future research center programs should have built-in training components, as with the Programs of Excellence in Molecular Biology and the Programs for Genomic Applications, to facilitate rapid dissemination of the new knowledge produced in these programs.
4. Training at the pre- and postdoctoral levels should include “survival skills” such as grant and manuscript writing, public speaking, obtaining funding, and promoting effective collaborations.
5. Specific requirements in training programs should begin to include such mathematically-based areas as bioinformatics, statistics, and dynamic analysis, when relevant. Programs in disciplines related to clinical research should also include training in epidemiology, clinical trials, and behavioral science.
6. Collaboration between academia and private industry should be pursued to help build needed competencies in mathematics and science.
7. Retraining programs and opportunities such as mini-sabbaticals should be provided for mid-career investigators who wish to redirect their studies and pursue new scientific objectives.
8. The academic award (K07) mechanism should be examined for its potential in enhancing training in functional genomics and other under-represented fields of promise, leading to the development of networks for training in research on heart, lung, blood, and sleep disorders.

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9. Consideration should be given to providing the full costs of tuition for postdoctoral course work, including those leading to Master of Science (M.S.), Master of Public Health (M.P.H.), or similar degrees.
  10. Support should be provided for both faculty and trainees to attend appropriate workshops and conferences for further education.

## **B. Multidisciplinary Collaboration**

Participants recognized that the enormous gains in knowledge produced by programs such as the mapping of the human genome may well revolutionize approaches to understanding disease pathogenesis, clinical care, and health maintenance. This potential can only be realized if that knowledge is fully integrated with basic physiology and biology to allow a full understanding of, for example, gene products and their interactions. Capitalizing on rapid evolutions in knowledge in this domain and others like it will require broadly-trained investigators, but no one individual can encompass all of the knowledge and skills necessary for further progress. Participants cited the “NASA model” as applying to biomedical research—just as no single person can build, pilot, and control a space shuttle, so nowadays biomedical research must be conducted by well-integrated groups of individuals combining their own unique areas of expertise.

The need for collaboration to facilitate future research advances was seen by workshop participants as paramount. This will imply more teamwork and less independence on the part of investigators, whose training must be redesigned accordingly. New reward systems may need to be developed to recognize successful contributions to interdependence in research. There may indeed be a need to address the current rank and tenure system in academia, which may place undue emphasis on the independent R01 grant.

Participants identified innovation and collaboration as two principal ingredients of a successful research program for the 21st century. They felt that new joint endeavors by investigators trained in a variety of scientific disciplines will emerge as the most successful approaches in the coming decades. Teamwork in the sense of the “NASA model” will be vital to future research, with independent, yet interdependent contributions by groups of specialists. The individual must be broad in interests, while highly specialized in research skills. Multidisciplinary approaches will be essential as science evolves; the next generation of scientist must be equipped to move rapidly into new disciplines as they emerge.

Participants also identified research networks as having considerable potential to facilitate multidisciplinary training. The NHLBI supports numerous research networks and multicenter studies that would provide a fertile ground not only for training new investigators in specific disciplines, but also for exposing them to related disciplines and providing practical experience in the intricacies of collaborative research. Experience with training in NHLBI programs such as the Programs of Excellence in Molecular Biology and the Comprehensive Sickle Cell Centers has been very positive and could be expanded to involve many similar programs.

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Research itself and the training to perform it would benefit greatly by increased contact among investigators and trainees at different institutions, perhaps by utilizing the concept of the “virtual center.” These could be formed by collaboration among multiple institutions geographically remote from each other, but having specific expertise and brought together to address a common problem. Current electronic communications make such a concept a viable proposition. Using similar approaches, it should be possible to share the best of local curricula, where institutions with particular strengths could complement each other by shared training programs. Indeed, an appeal to the creativity of the scientific community by a solicitation for suggestions of novel approaches to training linked to multidisciplinary research projects would be most beneficial.

Participants felt that all training programs should be encouraged to engage in collaboration, where institutions having special strengths or resources may share these with others having different qualities to offer. Trainees in such circumstances would be encouraged to develop a range of research skills and approaches, and would come to appreciate the advantages of seeking and establishing effective collaborations. From a national perspective, the suggestion was made to establish a United States Science Academy, along the lines of specialization offered by the military academies, providing an experience of natural science in all its breadth and depth to the potential research worker.

Participants expressed concern that current support mechanisms need to be more flexible to meet rapidly changing needs of scientific training and the settings in which it occurs. For example, it may be necessary to highlight the availability of mechanisms such as the Clinical Investigator Development Award (K08) to encompass currently underserved areas such as bioinformatics. Career development awards may need to be extended in duration in specific instances, to allow time for new contacts and liaisons to be developed. Existing programs should be given more widespread and effective exposure, with success stories and individual career tracks made clear at all levels of education. NIH-wide support for multidisciplinary training programs should be emphasized and communicated throughout the academic community, which will likely find a way to develop them. Particular attention may be needed to revising review criteria to encourage multidisciplinary approaches without incurring undue criticisms of vagueness or lack of focus. Participants felt strongly that if the NIH emphasizes and targets support for multidisciplinary training programs, academic centers will find a way to develop them.

***Recommendations related to multidisciplinary collaboration:***

1. At all stages of education and training, the NHLBI should foster broad, multidisciplinary approaches to research, including encouragement of interaction and collaboration among trainees in related disciplines.
2. A solicitation should be issued to the scientific community for support of novel programs of research training, to emphasize multidisciplinary team approaches, networking, and collaboration, emphasizing the competencies needed for the future of biomedical research.

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3. Virtual centers of excellence in research training should be encouraged, particularly in fields in which it is difficult to capture all necessary related disciplines in a single institution.
  4. Trainees should be encouraged to widen the scope of their interests and capabilities, so as to avoid too narrow a focus on research problems and to develop the flexibility necessary for an uncertain future of new scientific developments.
  5. A “Visiting Scholars Program” should be developed with a rapid application and review process (similar to the current Minority and Disability Supplement Programs) to encourage interactions of trainees with established centers of excellence for the acquisition of specific skills available at relatively few institutions.
  6. A multidisciplinary approach should be applied to training support at the NIH as well as in academia, as multidisciplinary training programs are rarely limited to a single Institute’s domain.
  7. Cognizant of the fact that the financial support and structure of academic medical research centers is currently endangered, strong alliances should be forged among industry, government, and academia in the provision of new research training programs.
  8. Small institutions having particular but limited strengths and facilities should be encouraged to collaborate with similar institutions with complementary strengths, in joint training awards.
  9. University rank and tenure systems, and the NIH as a whole, should reduce emphasis on independent R01 research support, providing more visibility to multidisciplinary team approaches.
  10. Frequent meetings should be held among fellowship and career development awardees to develop peer support systems.

### **C. Recruiting and Retaining Capable Investigators**

Participants expressed uniform concern over the declining numbers and potentially inadequate prior preparation of new trainees in the biomedical sciences. Disincentives for choosing science as a career (and, once in science, for choosing a research career), including perceptions that it is boring, that training takes too long, and that it is not sufficiently remunerative, need to be addressed aggressively by the scientific community if the pipeline of trainees is to be maintained. Participants felt that, in general, the research enterprise is largely unrecognized and underappreciated by society at large, giving less than a sense of excitement and worthiness that should characterize the pursuit of knowledge. They suggested that the exposure of students to science at the high school and college needs to highlight the excitement, challenge, and rewards

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of a career in scientific research. Participants also recognized that qualified faculty needed to train subsequent generations of researchers are being lost to industry, promising candidates are not entering training, and temporary residents from foreign countries (who often return home after their training) are increasingly filling the void in qualified trainees. The trainee “pipeline” was a topic of great concern with many ideas expressed about changing the current public perception of science and engaging the attention of students about the worthiness and satisfaction of a career in biomedical research.

Participants were somewhat divided as to the role of the NHLBI and the NIH in increasing the exposure of primary and secondary school students to the excitement of science. They felt that efforts by research institutions to offer experiences to students and teachers at the K-12 levels by “hands-on” laboratory time, possibly during summer sessions, would be useful. Visits to schools by scientists willing and able to make appropriate and interesting presentations would also be valuable. Stipend support and opportunities for science teachers, whether as teacher/fellows or as collaborators with investigators on research projects, would also be productive. At the undergraduate and graduate levels, similar attempts to interest potential biomedical investigators should be pursued.

Concern was expressed about postdoctoral trainees who, though they already have a commitment to science as a career, may not necessarily be committed to a full-time research career. Participants suggested that postdoctoral trainees each have a detailed career development plan designed to foster their development as capable researchers and designed to keep them in science and academia to the greatest degree possible.

Practical aspects of recruiting and retaining trainees were also addressed, including the limited levels of salary and research support currently provided. Participants recommended that trainee stipends be increased and escalated annually to accommodate cost-of-living increases, that consideration be given to a differential locality allowance, and that indirect costs of research be better supported. They felt that such financial incentives would do much to ensure retention in the research arena. They also recommended that the NHLBI consider a program of debt forgiveness for trainees who enter and remain in targeted areas of research such as bioinformatics or functional genomics. Some prospects should also be considered for bridging the gap between the K08 and R01 awards, currently an area where many nascent research careers come into jeopardy. Participants felt that a renewable career development award or consideration of reinstating the R29 (“FIRST” award) might be helpful in this regard. In the National Human Genome Research Institute, for example, the K01 (Research Scientist Development Award) has been targeted to physicists, chemists, and mathematicians with salary caps at current NIH-wide levels (\$125,900).

The role of industry in supporting and providing training to biomedical researchers was also addressed, with industry viewed as an important and under-utilized potential partner in this enterprise. Participants felt that preparation of trainees for careers in the biotechnology industry and other industry posts was a valid, but certainly not a primary, goal of NIH-supported training

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programs. They also felt that the biomedical industry should be encouraged to contribute to the provision of research training, both directly, through the expertise of its scientists, and indirectly, through funding of such efforts by academic research centers.

***Recommendations related to recruitment and retention:***

1. Consideration should be given to substantial increases in trainee stipends so that trainees are able to finish their training without a crushing load of debt.
2. For those already having incurred significant educational debts, a debt-reduction plan should be considered to forgive training-associated debt at the rate of, for example, \$10,000 per annum for a maximum of 10 years, provided the trainee remains in biomedical research for that period.
3. The NHLBI should establish teacher/fellow awards, for summer studies and research projects in research institutions to generate interest in science and improve teaching abilities. Consideration should be given to supporting visits by scientists to schools to speak about their research.
4. Availability of NHLBI training programs should be more widely advertised, through editorials, letters to institutional administrators, and establishment of institutional liaisons or faculty members as specific points of contact with the NHLBI.
5. New mechanisms of support may be needed to bridge the gap between the K08 and the R01, a stage at which many new researchers find themselves in financial limbo. Reinstatement of the R29, and the possibility of renewing K series awards would help in this regard.
6. Areas of short-term need (10-20 years) should be recognized, including physician-scientists, informatics/ biostatistics, behavioral disciplines, integrative sciences (physiology), and clinical trialists.
7. A shift of emphasis may be needed in the way the NIH supports training from numbers to quality of trainees and their training experience.
8. The NHLBI should consider supporting an educational program, along the lines of its current national education programs (such as the National High Blood Pressure Education Program and the National Asthma Education and Prevention Program), but designed to educate the public about the value to society of biomedical research.
9. Improved support should be included in training grants for training-related expenses, with the current institutional allowance of \$1,500-2,500 raised several-fold and consideration given to providing increased indirect costs.



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10. Payback requirements should be clarified as they currently are intimidating to some trainees; consideration should be given to eliminating payback.
  11. To foster early interest in biomedical science, consideration should be given to supporting summer programs for students K-12 to provide for structured, supervised experiences in laboratories and clinics in research institutions, and to provide teachers with resources to develop “hands-on” learning experiences related to biomedical research.
  12. Approaches for interacting effectively with industry in providing training should be developed, such as including industry scientists as mentors on training grants or providing short-term experiences in industry settings for trainees.
  13. Development of partnerships between the NIH and industry should be considered in funding training programs, as industry has been a major beneficiary of NIH-sponsored programs.

## **D. Mentorship**

The importance of strong mentorship and the many current threats to its practice formed a recurring theme throughout the discussions. Because mentors provide a key element in recruiting and retaining talented trainees, as well as providing them the scientific background necessary for them to succeed in research, issues related to mentorship are included here.

Workshop participants recognized that the role of the mentor is frequently ill-defined and that it may receive inadequate emphasis during review of training, fellowship, and career development grant applications, but that it is crucial at all steps in career development. For example, newly-matriculated graduate students who spend most of their time in course work need advice about choices of courses, as well as a breadth of exposure to different disciplines and an initiation into methods of scientific inquiry and investigation. Graduate students need to be quickly brought into personal contact with key faculty, visiting scientists, and their peers; this is the responsibility of the mentor. Later in graduate studies, when commitment to a particular line of inquiry has been made, the mentor should foster creative and independent thinking, help with daily problem-solving and act as a role model for work habits and scientific integrity. There should be constant assessment and oversight of research techniques, data analysis, thought processes, attitudes, and ethics. During the trainee’s maturation from student to research fellow, the mentor should ideally challenge current ideas and dogma, with insights from an historical perspective, while encouraging the development of communication skills and ensuring exposure at scientific and departmental meetings.

Participants felt a distinction could and should be made between “local” mentoring on the one hand and “global” mentoring on the other. Local mentoring entails interaction with the trainee on a one-to-one basis, with ongoing advice on a daily basis and where the relationship is of the nature of the master-apprentice. Global mentoring implies teamwork, with interactions among faculty and students in the context of a joint approach to problems, where the whole team must

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mentor, and where interactive multidisciplinary science is emphasized. The latter is an important concept for training in the coming decades. In the words of one participant, it “takes a village” to create a modern scientist.

Several avenues exist by which mentoring can be brought to appropriate levels of excellence. Training program directors and their faculties should be evaluated as mentors and should be required to provide specific mentoring plans for trainees. Study sections should be encouraged to focus on mentoring as a critical evaluation element in their reviews of training grant applications. Funds to support mentoring activities should be provided in proportion to time spent, just as in research-related activities. Training programs should be evaluated on their ability to provide the multidisciplinary mentoring necessary for the multidisciplinary nature of future biomedical research. Training for excellence in mentoring is needed, with courses and guides on best practices made available to seasoned scientist and young investigator alike. Mentors should have certain expectations of support by their institutions, for example with recruitment, registration, course scheduling, and support of student activities. Trainees should have a clear understanding of what to expect from a mentor and what their own responsibilities, such as diligent effort and responsiveness to criticism, are in return.

A crucial role for the mentor is emerging in modern research, where there is a clear need to develop investigators skilled in multidisciplinary teamwork. The goal should be to extend the trainee both technically and intellectually beyond doctoral training, to position him or her as a flexible investigator and active collaborator, able to share commitments of time and ideas with confidence and success.

Participants felt that the ideal mentor should maintain constant oversight and assessment of the trainee, with daily problem-solving, following a comprehensive, long-term development plan, established at the start of training and modified as needed. Mentorship should go well beyond the simple assignment of routine tasks and should become a constant presence in all phases of trainee development. Participants also felt that support should be provided to the mentor for such activities, perhaps amounting to 5-10% level of effort, with perhaps up to 5% provided to the other members of the global mentoring team.

A guide to professional mentorship would be a welcome resource for all who supervise trainees, possibly linked to a program of mentorship training. The NIH Intramural Program has published a Guide to Training and Mentoring, which is available at:

<http://www1.od.nih.gov/oir/sourcebook/ethic-conduct/mentor-guide.htm>

The National Academy of Sciences has an extensive mentorship guide available at:

<http://www.nap.edu/readingroom/books/mentor/>

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Participants suggested that review of training grant applications should require evaluation of actual or potential quality of mentorship, and the successful outcomes of such grants should recognize indices of accomplishment by trainees that extend beyond the simple acquisition of independent funding, emphasizing instead team approaches and flexibility as the hallmarks of future success. “Training” programs that treat trainees as a ready source of skilled labor, without providing broader training or career development, should be identified and their program directors obliged to meet their training responsibilities or face loss of training support.

***Recommendations related to mentorship:***

1. A summary of best practices for high quality mentoring should be developed and made widely available.
2. Training programs for mentorship, analogous to other available short courses, should be developed and offered at the NIH or as a satellite to national meetings. These should include guidance on approaches to multidisciplinary mentorship.
3. The NHLBI should provide specific criteria for the evaluation of mentorship on T32 grant applications and renewals, and should require an example of a detailed mentoring plan and the process by which such plans will be developed for future trainees.
4. Academic institutions should be encouraged to support mentoring, in terms of institutional administrative support, protected time for mentoring, departmental support for student activities, and conscientious interaction and effort by student/fellow.
5. Programs using trainees as a convenient source of skilled labor without providing formal training opportunities should be identified and their program directors obliged to meet their training and career development responsibilities.
6. Emphasis should be placed on the concept of “global mentorship”, where all of the senior partners in team-based research lend their individual expertise to the trainee, with the overall guidance of the training program director.
7. Consideration should be given to targeting mentorship support for faculty in needed areas, such as allowing a biostatistician 10% supported time on training grants to develop that expertise among trainees.

**E. Diversity in the Workforce**

Workshop participants recognized the need for the research workforce of the future to reflect the cultural and ethnic diversity of the American population to the greatest extent possible. Special measures were felt necessary, however, to encourage engagement by minorities in the biomedical research enterprise. Participants noted that many minority physicians feel a strong altruistic

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motive to return to deliver medical care in the underserved areas of their origins, which may mitigate against a research career in a major medical center. A salient need is to interest young people of racial/ethnic minorities and to encourage them to enter the pipeline at the start of their education. Recruitment efforts should begin at the high school level or before. A focused effort on minority recruitment with strong institutional support has been demonstrated to have substantial success. In Houston, Texas, for example, minority high schools for science have been implemented, in collaboration with medical school faculty. Many graduates of these schools have pursued careers as medical technicians and other auxiliary medical personnel, but a proportion goes on to doctoral studies. Special training is given in preparation for the Medical College Admissions Test (MCAT). The basic problem appears to be how to make biomedical science seem fascinating and irresistible to a group for whom it may currently appear remote and inaccessible.

An additional problem is the shortage of mentors and successful role models, at the college level and beyond, who are themselves members of racial/ethnic minority groups. In 1999 only 3% of medical school faculty in America were minorities. Mentors who are courageous, passionate, and visionary can encourage students to excel, but they are few and far between. Networks of dedicated faculty willing to mentor minority students would be well worth developing.

A brief description of the Meyerhoff Scholars Program at the University of Maryland Baltimore Campus provided an engaging example of a successful approach to increasing the diversity of the research workforce. This program has been singularly successful in recruiting and retaining African American men in college science and engineering programs. The Meyerhoff program identifies outstanding high school students and provides a full 4-year college scholarship, a personal computer, and strong personal academic support. A summer residential bridging program provides a transition to college studies, and parents are encouraged to play a major role in this process. Small groups of students work with tutors throughout the college years, and weekly meetings with the Program Director provide opportunities for problem solving. In the early years, mathematics and science are introduced gradually, but graduation as a science or engineering major is the intended outcome. The Meyerhoff scholars not only earn solid academic records, but adjust well to college life in the full sense. Many have gone on to receive doctoral degrees in science. The combination of a pre-freshman summer transition program, special tutoring and help in decision-making, and group study, has clearly increased the number of minority students able to pursue successful careers in science and engineering.

Participants agreed that a major goal of future research programs must be to ensure that the composition of the community of biomedical investigators truly reflects the cultural and ethnic diversity of the nation.

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### ***Recommendations related to workforce diversity:***

1. The NHLBI should support the development of a Minority Scientist Mentorship Network among scientists with research expertise and experience who are dedicated to the ideal of diversity in the workforce.
2. Special attention should be given to financial pressures faced by minority trainees, with targeted debt forgiveness or stipend adjustment considered in areas of particular need.
3. Support should be provided for summer experiences and training for teachers in schools for underrepresented minorities.
4. Academic Awards or Centers of Excellence in genomics, or similar fields of expanding opportunities, should be developed to provide a general research infrastructure and training programs in these fields at minority institutions.
5. Efforts should be redoubled to provide stable and consistent research support for minority investigators, as a means to ensure their retention as role models.
6. Special accommodation should be provided for trainees beginning families, by avoiding rigid scheduling and providing greater flexibility in career program development.
7. An institution's complete portfolio of training programs should be considered in evaluating its efforts in fostering diversity, to encourage intra-institution collaboration in recruitment and avoid competition for minority candidates among multiple programs within an institution.

## **F. The Special Case of Clinical Research**

Participants expressed uniform concern that the clinical investigator is fast becoming an endangered species, and that immediate steps are necessary to correct the situation. The physician-scientist is uniquely capable of translating basic research advances from the laboratory to the clinic—surely the *raison d'être* of biomedical research.

A major deterrent to a career in research for the physician is financial. Most physicians graduate with an enormous debt burden and face strong pressures to maximize their income. The relatively low stipends of research training awards and the uncertainties of a future career in research are sufficient to deter many who might otherwise pursue successful and rewarding research careers. Reduction of these early financial barriers might be a major step in facilitating entrance of talented physicians to the research workforce.

Participants felt that active steps to encourage physicians to enter a scientific research career should include debt reduction or forgiveness as a major inducement. They felt that additional

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years of training beyond the prolonged training of medical school may be less of an obstacle than a burden of debt at the end. Debt reduction programs provided in increments over several years, provided the individual remains in research, were suggested as a strong enticement to retention. Consideration might be given to paying for multiple years of education and training after medical school by service in a National Research Corps.

Another important consideration is the protection of adequate time for research for the clinician. Too frequently physicians in research training are called upon to “pick up the slack” in clinical responsibilities, much to the detriment of a need to focus for undisturbed periods of time on a research project. Many workshop participants felt that at least 50% protected time must be guaranteed for the serious clinical scientist.

Participants suggested that special curricula be developed for physicians, with attention to subjects least well represented in medical training, such as genomics, integrative science, or bioinformatics. One of the most important tracks followed by clinical scientists may be the M.D.-Ph.D. program. Individuals with the joint degrees are especially well qualified and adept at translational research. Such programs deserve strengthening and extending. Recognition that physicians who acquire a Ph.D. at the end of fellowship years (rather than in joint M.D.-Ph.D. programs in medical schools) tend to stay in research should lead to greater support for this particular track.

Participants also expressed concern that the traditional structure and culture of the academic medical center is threatened by managed care, and that new approaches to training will have to evolve with the inevitable changes taking place. Clinical researchers cannot be considered as unencumbered profit-makers for the institution. Inclusion of research topics on clinical rounds might provide a needed shift away from a perceived emphasis on length of stay and cost of care issues.

Participants noted that the loss of junior physicians to research is most evident at the assistant professor level, when career development awards such as the K08 are ending but before an R01 can be acquired. They felt that bridging mechanisms are needed here, perhaps a new grant altogether, or the reinstatement of the R29, or competing renewal of career development awards.

Participants also recognized that appropriately prepared Ph.D. scientists are likely to function well in clinical research. Better preparation of Ph.D.s to do clinical research is needed; Ph.D. students often enter the biomedical sciences with a desire to help people and advance medicine but once involved in basic laboratories they may become distanced from human disease. Training for Ph.D. students in the pathophysiology of disease, or in behavioral medicine or other human sciences, would address this need. Currently there are no NIH mechanisms to support such training. Consideration might also be given to pairing M.D. and Ph.D. investigators as joint principal investigators (PIs) on a single grant.

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An understanding of disciplines related to clinical practice, such as health services research, epidemiology, and clinical trials, would be valuable for the clinical researcher. These and similar issues might best be dealt with by implementation of clinical training networks, linked perhaps to existing NHLBI-sponsored research networks and centers. New approaches to preparing clinical investigators might include advanced degree programs at the master's level, in biomedical science, epidemiology, and clinical trials for physicians, and human studies for Ph.D. scientists.

The critical shortage of clinical investigators requires urgent attention. Much encouragement and support of M.D.-Ph.D. programs is necessary to provide the highest quality of clinical investigator. Protected research time is vital to the success of these programs. Early exposure to the laboratory for medical students has been linked to graduation as M.D. with research honors with great success. Experiences for physicians could include master's degree programs, for example in physiological genomics or epidemiology/clinical trials, with full tuition expenses provided. Subspecialty fellowships for board certification could be designed to include graduate school studies in basic sciences. In all cases a multidisciplinary approach should be encouraged. For Ph.D. scientists, there is merit in providing specialized training in clinical sciences to enable engagement in human subjects research or clinical trials.

***Recommendations related to clinical research:***

1. A program of support should be created specifically for M.D.-Ph.D. investigators, to extend and diversify postdoctoral training.
2. Support should be provided for a structured program of research experience for medical students, resulting at graduation in a medical degree with research honors.
3. Clinical training networks should be established, linked to current NHLBI-sponsored research networks and multicenter studies.
4. Programs of clinical relevance should be established for Ph.D. scientists, with an emphasis on postdoctoral training and course work in human biology and behavioral science, with a view to subsequent engagement in human subjects research or clinical trials.
5. Consideration should be given to awarding "joint" PIs, i.e., M.D. and Ph.D., jointly funded by a single grant to pair basic science and clinical work, as all expertise need not be concentrated in one person but both must get credit.
6. Increased flexibility in providing support for expanding capabilities of Ph.D. scientists is needed, such as K awards for Ph.D.s to do clinically-relevant research in biomedical sciences.
7. The K02 is a good mechanism for those with independent funding but it does not seem to be widely known; this may be communication problem.
8. A Physician-Scientist Special Recognition Award for excellence in clinical research should be established.

## Appendix 1

### SPEAKERS AND EXPERT PANELISTS

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- 2:30 p.m.**     **2B: *Competencies for the 21st Century***  
                  **Brian Duling**, University of Virginia  
                  **Allan Pack**, University of Pennsylvania  
                  **David DeMets**, University of Wisconsin
- 3:30 p.m.**     *Break*
- 4:00 p.m.**     **2C: *Perspectives from Grantees***  
                  **Gerardo Heiss**, University of North Carolina  
                  **Bruce Furie**, Harvard University  
                  **Serpil Erzurum**, Cleveland Clinic Foundation  
                  **Linda Kao**, Johns Hopkins University
- 5:00 p.m.**     *First day ends*

*Wednesday, November 3*

- 8:30 a.m.**     **SESSION 3**    Chair: **James Crapo**
- 3A: *Mentorship***  
                  **Karen Matthews**, University of Pittsburgh  
                  **Allen Cowley**, Medical College of Wisconsin  
                  **Jeffrey Drazen**, Harvard University
- 9:30 a.m.**     **3B: *Innovative Support Mechanisms***  
                  **Hal Broxmeyer**, Indiana University  
                  **James Wilson**, University of Pennsylvania  
                  **Barry Stripp**, University of Rochester
- 10:30 a.m.**    *Break*
- 11:00 a.m.**    **3C: *The Special Case of Clinical Research***  
                  **Michael Welsh**, University of Iowa  
                  **Franklin Bunn**, Harvard University  
                  **Jeffrey Drazen**, Harvard University
- 12:00 noon**    *Lunch*
- 1:00 p.m.**     **SESSION 4**    Chair: **Elizabeth Nabel**
- CLOSED EXECUTIVE SESSION**
- 4:00 p.m.**     *Workshop ends*

## Appendix 3

### INVITED DISCUSSANTS

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## Appendix 4

# NIH Training and Career Development Awards

*NOTE: Information contained herein should be considered provisional and subject to change; consult individual Institutes/Centers for the most up-to-date information.*





# Description of T Award Mechanisms

## **T15 Continuing Education Training Grants**

To assist professional schools and other public and nonprofit institutions to establish, expand, or improve programs of continuing professional education, especially for programs of extensive continuation, extension, or refresher education dealing with new developments in the science or technology of the profession.

## **T32 Institutional National Research Service Award**

To enable institutions to make National Research Service Awards to individuals selected by them for predoctoral and postdoctoral research training in specified shortage areas.

## **T34 MARC (Minority Access to Research Careers) Undergraduate NRSA Institutional Grants**

To enable minority institutions to make National Research Service Awards to individuals selected by them for undergraduate research training in the biomedical and behavioral sciences.

## **T35 NRSA Short-Term Research Training**

To provide individuals with research training during off-quarters or summer periods to encourage research careers and/or research in areas of national need.

## **T36 MARC Visiting Professors for Minority Institutions (NIGMS)**

To increase the number of well-trained minority scientists in biomedical disciplines and to strengthen the research and teaching capabilities of minority institutions through a variety of training mechanisms such as visits by experienced scientists to minority institutions or workshops/conferences designed to enhance the research training experience of students/faculty from minority institutions.

## **T37 Minority International Research Training Grants (FIC)**

Institutional training grants awarded to domestic institutions supporting opportunities for biomedical and behavioral research training for minority students and faculty members at foreign sites.



# Description of F Award Mechanisms

## **F06 Senior International Fellowships (FIC)**

To provide opportunities to outstanding mid-career faculty members from U.S. schools of medicine, osteopathy, dentistry, and public health with demonstrated productive scholarship and recognized stature in their profession to go abroad to study and share their expertise.

## **F30 Individual Predoctoral NRSA for M.D./Ph.D. Fellowships (ADAMHA)**

Individual fellowships for predoctoral training which leads to the combined MD/PhD degrees.

## **F31 Predoctoral Individual National Research Service Award**

To provide predoctoral individuals with supervised research training in specified health and health-related areas leading toward the research degree.

## **F32 Postdoctoral Individual National Research Service Award**

To provide postdoctoral research training to individuals to broaden their scientific background and extend their potential for research in specified health-related areas.

## **F33 National Research Service Awards for Senior Fellows**

To provide opportunities for experienced scientists to make major changes in the direction of research careers, to broaden scientific background, to acquire new research capabilities, to enlarge command of an allied research field, or to take time from regular professional responsibilities for the purpose of increasing capabilities to engage in health-related research.

## **F34 MARC NRSA Faculty Fellowships**

To provide fellowships to selected faculty members from minority institutions to enable them to obtain advanced training in specified health and health-related areas.

## **F38 Applied Medical Informatics Fellowship**

To provide opportunities for scientists to make major changes in the direction of research careers for the purpose of engaging in the synthesis, organization, and management of knowledge.



# Description of K Award Mechanisms

## **K01 Research Scientist Development Award - Research and Training**

For support of a scientist, committed to research, in need of both advanced research training and additional experience.

## **K02 Research Scientist Development Award - Research**

For support of a scientist, committed to research, in need of additional experience. (At NHLBI, existing research support is required)

## **K05 Research Scientist Award**

For support of a research scientist qualified to pursue independent research which would extend the research program of the sponsoring institution, or to direct an essential part of this research program.

## **K07 Academic/Teacher Award**

To create and encourage a stimulating approach to disease curricula that will attract high quality students, foster academic career development of promising young teacher-investigators, develop and implement excellent multidisciplinary curricula through interchange of ideas, and enable the grantee institution to strengthen its existing teaching program.

## **K08 Clinical Investigator Award**

To provide the opportunity for promising medical scientists with demonstrated aptitude to develop into independent investigators, or for faculty members to pursue research aspects of categorical areas applicable to the awarding unit, and aid in filling the academic faculty gap in these shortage areas within health profession's institutions of the country.

## **K12 Physician Scientist Award**

For support of a newly trained clinician appointed by an institution for development of independent research skills and experience in a fundamental science within the framework of an interdisciplinary research and development program.

## **K15 Dentist Scientist Award (Individual)**

To provide support for dentists with a strong commitment to oral health research to develop into independent biomedical investigators. Primarily for support of a newly trained dentist *nominated* by an institution for development of independent research skills through a three-phase program: advanced basic science development, advanced clinical science development, and a research experience component.

**K16 Dentist Scientist Award (Program)**

To provide support for dentists with a strong commitment to oral health research to develop into independent biomedical investigators. Primarily for support of a newly trained dentist *appointed* by an institution for development of independent research skills through a three-phase program: advanced basic science development, advanced clinical science development, and a research experience component.

**K22 Career Transition Award**

To provide support to outstanding newly trained basic or clinical investigators to develop their independent research skills through a two-phase program: an initial period involving an intramural appointment at the NIH, and a final period of support at an extramural institution. The award is intended to facilitate the establishment of a record of independent research by the investigator in order to sustain or promote a successful research career.

**K23 Mentored Patient-Oriented Research Career Development Award**

To provide support for the career development of investigators who have made a commitment to focus their research endeavors on patient-oriented research. This mechanism provides support for a 3-year minimum up to a 5-year period of supervised study and research for clinically trained professionals who have the potential to develop into productive clinical investigators.

**K24 Midcareer Investigator Award in Patient-Oriented Research**

To provide support for clinicians to allow them protected time to devote to patient-oriented research and to act as mentors for beginning clinical investigators.

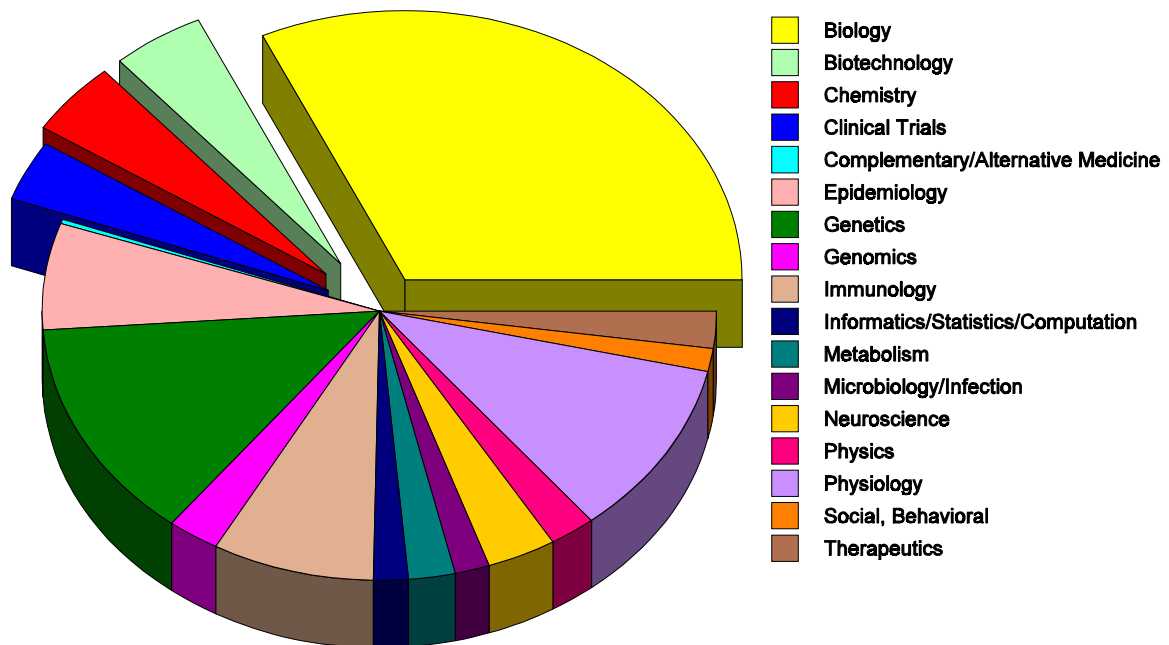
**K25 Mentored Quantitative Research Career Development Award**

Provides research and career development opportunities for scientists and engineers with varying levels of research experience in biomedicine or behavior, who are committed to establishing themselves in careers as independent biomedical investigators.

**K30 Clinical Research Curriculum Award**

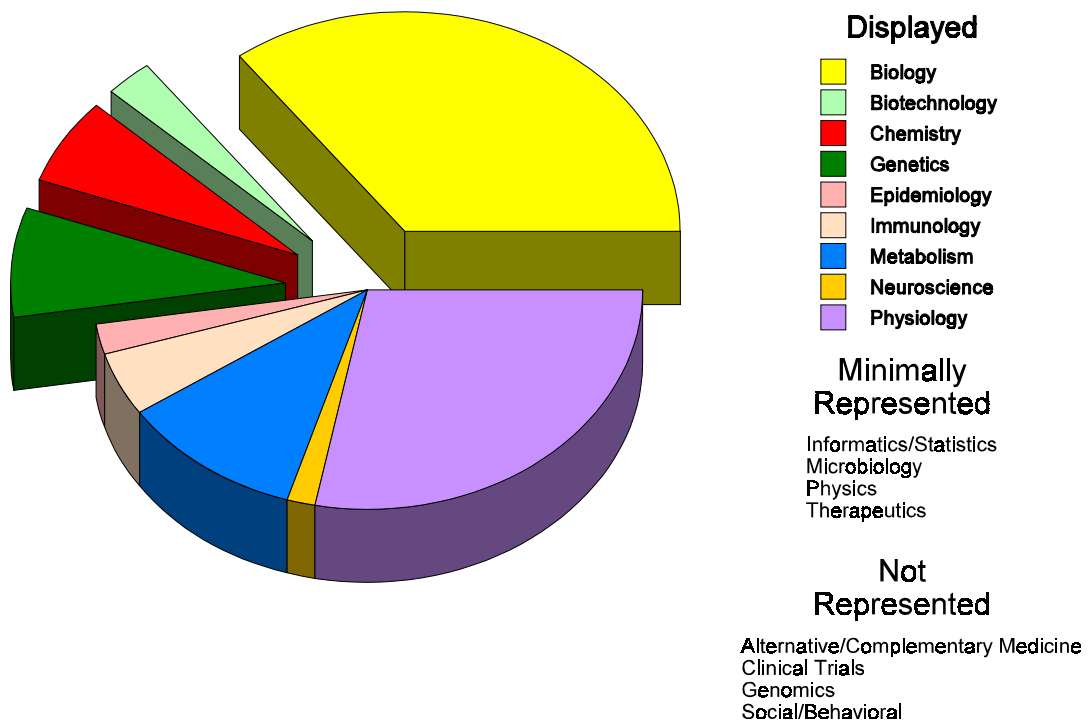
Award to institutions intended to stimulate the inclusion of high-quality, multidisciplinary didactic training as part of the career development of clinical investigators. This award is intended to support the development of new didactic programs in clinical research at institutions that do not currently offer such programs or, in institutions with existing didactic programs in clinical research, to support or expand their programs or to improve the quality of instruction.

NHLBI Trainees -- FY 1999  
n = 1,033



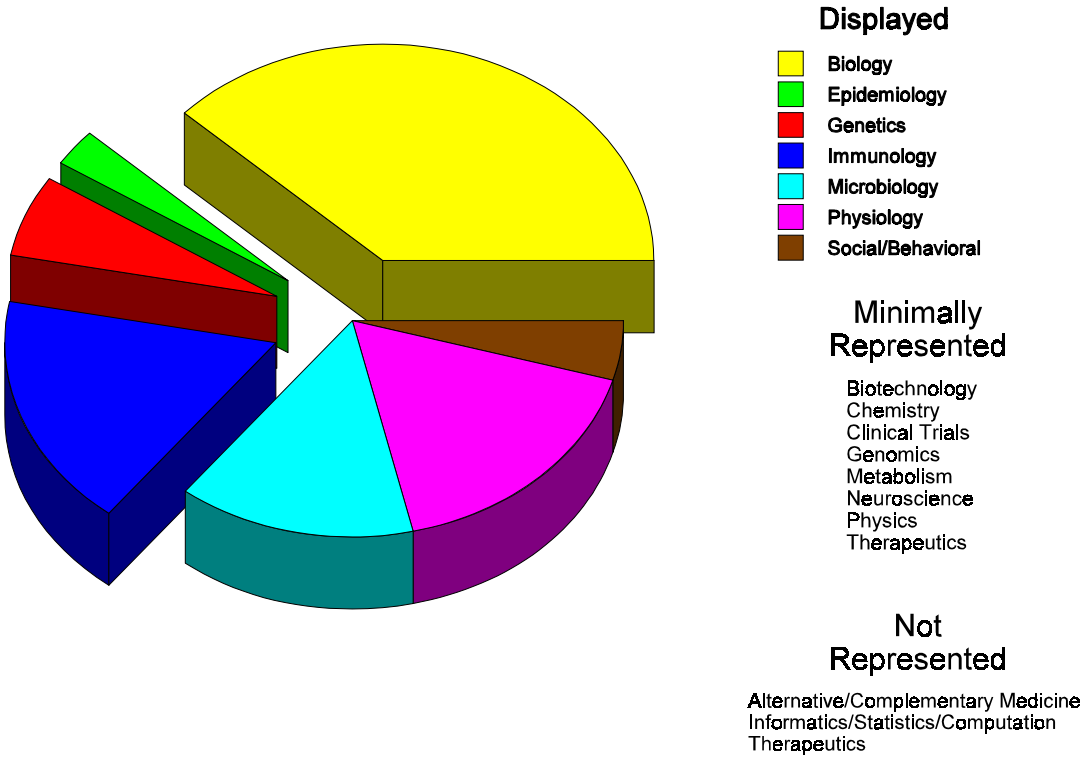
# NHLBI Fellowships and Career Development Awards -- FY 1999

## Heart and Vascular Program (n = 343)

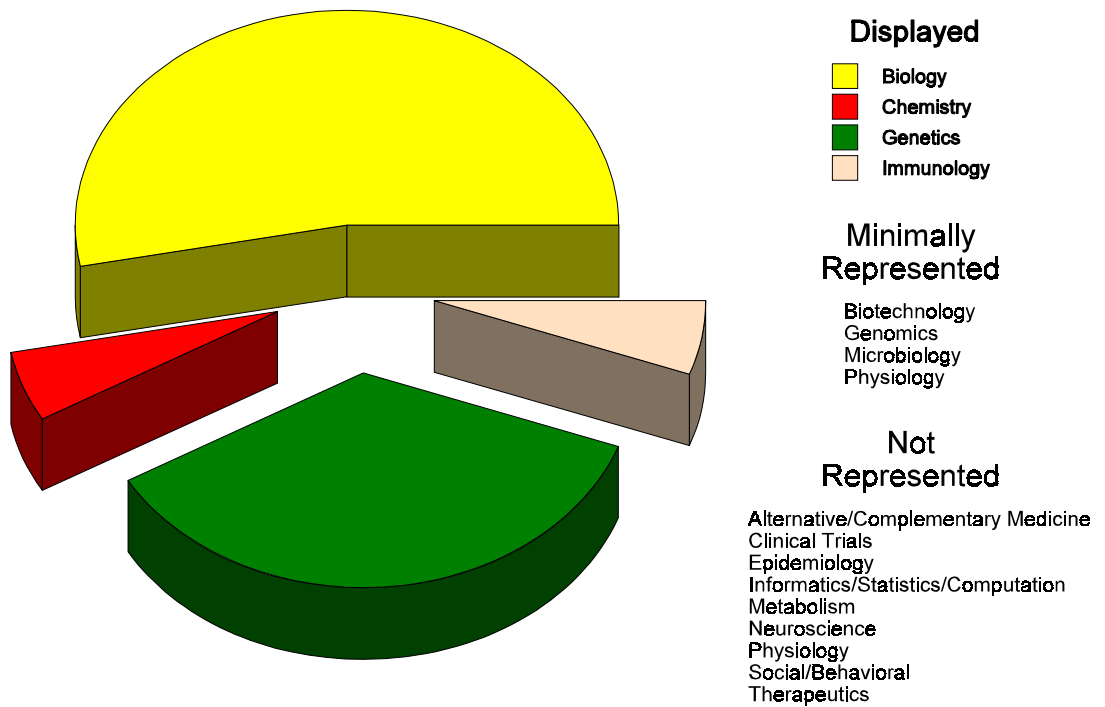




NHLBI Fellowships and Career Development Awards -- FY 1999  
Lung Program (n = 195)



NHLBI Fellowships and Career Development Awards -- FY 1999  
Blood Program (n = 102)



## Appendix 6

# Scientific Coverage by Current NHLBI Training Grants

### 1. **BIOLOGY**

- molecular biology
- cell biology
- developmental biology

### 2. **BIOTECHNOLOGY/BIOENGINEERING**

- cell processing/fermentation
- biomaterials
- devices and instruments
- imaging
- nanotechnology

### 3. **CHEMISTRY**

- biochemistry
- medicinal chemistry
- neurochemistry
- pharmacodynamics

### 4. **CLINICAL TRIALS**

### 5. **COMPLEMENTARY and ALTERNATIVE MEDICINE**

### 6. **EPIDEMIOLOGY**

- environmental and occupational medicine
- prevention and control

### 7. **GENETICS**

- molecular genetics
- developmental genetics
- immunogenetics
- pharmacogenetics
- behavioral genetics
- population genetics and pedigree studies
- gene therapy
- genetically altered animal model development

## 8. GENOMICS

- functional genomics
- structural genomics
- physiological genomics

## 9. IMMUNOLOGY

- inflammation
- immune regulation
- cellular and humeral immunity
- allergy
- vaccine development
- transplantation biology

## 10. INFORMATICS, STATISTICS, and COMPUTATION

- mathematical modeling
- biometry
- database management
- statistical analysis
- nonlinear dynamic analysis
- software development

## 11. METABOLISM

- enzymology
- biologically active substances
- synthesis and degradation of compounds
- nutrition

## 12. MICROBIOLOGY and INFECTION

- bacteriology
- virology
- pathogenesis

## 13. NEUROSCIENCE

- molecular neuroscience
- behavioral neurology
- cognitive neurology
- integrative neuroscience

## 14. PHYSICS

- biophysics
- structural biology

**15. PHYSIOLOGY**

tissue and organ systems  
aging  
integrative physiology  
exercise physiology  
endocrinology

**16. SOCIAL and BEHAVIORAL SCIENCE**

demography  
psychology  
behavioral medicine  
bioethics

**17. THERAPEUTICS**

pharmacological mechanisms  
drug metabolism  
pharmacokinetics  
pharmacodynamics  
toxicity and adverse effects  
clinical pharmacology

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