

**ADDRESSING THE  
NATION'S  
CHANGING  
NEEDS  
FOR BIOMEDICAL AND  
BEHAVIORAL SCIENTISTS**

Committee on National Needs  
for Biomedical and Behavioral Scientists

Education and Career Studies Unit

Office of Scientific and Engineering Personnel

National Research Council

NATIONAL ACADEMY PRESS  
Washington, DC

**NATIONAL ACADEMY PRESS • 2101 Constitution Avenue, N.W. • Washington, DC 20418**

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This study was performed under Contract No. N01-OD-7-2109 between the National Academy of Sciences and the National Institutes of Health. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the Committee on National Needs for Biomedical and Behavioral Scientists and do not necessarily reflect the view of the agency that provided support for this project.

Additional copies of this report are available from the National Academy Press, 2101 Constitution Avenue, N.W., Box 285, Washington, DC 20055; (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area); <http://www.nap.edu>.

Library of Congress Catalog Card Number 00-105076

International Standard Book Number 0-309-06981-5

Copyright 2000 by the National Academy of Sciences. All rights reserved.

Printed in the United States of America

# THE NATIONAL ACADEMIES

National Academy of Sciences  
National Academy of Engineering  
Institute of Medicine  
National Research Council

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. William A. Wulf are chairman and vice chairman, respectively, of the National Research Council.

## **Committee on National Needs for Biomedical and Behavioral Scientists**

### **Howard Hiatt, *Chair***

Professor of Medicine  
Harvard Medical School  
Senior Physician  
Department of General Medicine  
Brigham and Women's Hospital

### **Gail H. Cassell**

Vice President of Infectious  
Diseases  
Eli Lilly and Company

### **Janice G. Douglas**

Professor of Medicine and  
Physiology and Biophysics  
Vice Chair, Academic Affairs  
Case Western Reserve University  
School of Medicine

### **Richard B. Freeman**

Ascherman Professor of  
Economics  
Harvard University

### **Lee Goldman**

Julius R. Krevans Distinguished  
Professor and Chair  
Department of Medicine  
Associate Dean for Clinical Affairs  
University of California, San  
Francisco School of Medicine

### **Leland H. Hartwell**

President and Director  
Fred Hutchinson Cancer Research Center

### **John F. Kihlstrom**

Professor of Psychology  
University of California, Berkeley

### **Ellen M. Markman**

Associate Dean of Social Sciences  
Stanford University

### **Edward E. Penhoet**

Dean  
School of Public Health  
University of California, Berkeley

### **Steven A. Schroeder**

President  
Robert Wood Johnson Foundation

### **Michael S. Teitelbaum**

Program Director  
Alfred P. Sloan Foundation

### **Staff**

Rodolfo A. Bulatao, Demographer  
Charlotte Kuh  
Julie Parker, Senior Project Assistant  
Jennifer Sutton, Study Director  
James A. Voytuk

## Office of Scientific and Engineering Personnel Advisory Committee

**M. R. C. Greenwood, *Chair***  
Chancellor  
University of California, Santa Cruz

**John D. Wiley, *Vice Chair***  
Provost and Vice Chancellor for  
Academic Affairs  
University of Wisconsin, Madison

**Carlos Gutierrez**  
Professor of Chemistry  
California State University, Los Angeles

**Stephen J. Lukasik**  
Independent Consultant

**Ronald G. Ehrenberg**  
Irving M. Ives Professor of Industrial  
and Labor Relations and Economics  
Cornell University

**Edward Penhoet**  
Dean  
School of Public Health  
University of California, Berkeley

**Tadataka Yamada**  
Chairman, Research and  
Development  
SmithKline Beecham  
Pharmaceuticals

**A. Thomas Young**  
Former President and Chief  
Operating Officer  
Martin Marietta Corporation

**William H. Miller, *ex officio***  
Department of Chemistry  
University of California,  
Berkeley

**Claudia I. Mitchell-Kernan**  
Vice Chancellor of Academic  
Affairs and Dean  
University of California, Los  
Angeles

### Staff

Charlotte Kuh, Executive Director  
Marilyn J. Baker, Associate Executive Director

# Preface

This congressionally mandated report on the training of biomedical and behavioral researchers reviews the recent production and current supply of scientists and is the eleventh in a series that began in 1975. It makes recommendations for the size and scope of the National Research Service Award (NRSA) training program in the years ahead. Unlike earlier studies, it also considers research training mechanisms other than NRSA training grants and fellowships. As a result, this report devotes a great deal of attention to the balance between NRSA and non-NRSA training activities and the coordination between the two.

In addition, the report stresses the need for research training programs to keep pace with changes in the organization of science and the economic and social realities of health care. In contrast to the technical and methodological advances in biomedical and behavioral research that are routinely incorporated into research training programs, changes in the organization of science, the delivery of health care, and the nation's demography pose more difficult challenges. Addressing these challenges, which have a bearing on research training overall, will require the active involvement of the National Institutes of Health, the Agency for Healthcare Research and Quality, and the Health Resources and Services Administration to collectively take a more active role in research training.

In particular, the agencies responsible for research training must seek more effective ways to draw greater numbers of physicians and other health care professionals into research careers, to attract and prepare future investigators to address disparities in health status,

and to ensure that more investigators in all fields are prepared to conduct interdisciplinary health research.

The report was crafted by a committee of eleven, drawn from the fields of biomedical, behavioral, and clinical research, labor economics, and demography and for the most part represents the consensus of their views. One of our members, however, has offered a personal statement on funding for research and research training in the behavioral and social sciences; his views can be found in Appendix F.

The report also reflects the contributions of numerous others who generously shared their time and expertise. More than a hundred contributors responded to the committee's invitation to submit written comments on research training in the health sciences; their responses are summarized in Appendix C. Many others met with the committee or its chair to provide information and offer suggestions. Among the latter were Norman Anderson, Andrea Baruchin, Carol Bazell, David Blumenthal, Marvin Cassman, John Eisenberg, Suzanne Feetham, Susan Gerbi, Patricia Grady, Steven Hyman, Alan Kraut, Al Lazen, Richard McIntosh, David Nathan, John Norvell, Georgine Pion, Howard Schachman, Harold Slavkin, and Ellen Stover.

The committee is especially grateful to six scientists in training who candidly shared their experiences, including their struggles, in becoming independent investigators: Regis Krah, Krishna Mallik, John Otridge, Julie Ann Sosa, James Rowlett, and Marc Weisskopf. We wish them great success in their careers.

This report was made possible by funding from the National Institutes of Health and the willingness of

scores of staff members throughout the National Institutes of Health, the Agency for Healthcare Research and Quality, and the Health Resources and Services Administration to provide valuable information. At the National Institutes of Health, we are particularly indebted to Walter Schaffer, the project officer, for his patient guidance and good counsel, Deputy Director Ruth Kirschstein for her generosity with her thoughts and her time, and Robert Moore and Carol Bleakley of the Office of Reports and Analysis for the graciousness with which they fulfilled our repeated requests for data.

The committee owes special thanks to Don McMaster and his colleagues at Quantum Research Corporation for their skillful data analyses and to the staff members of many professional associations and societies who readily and generously shared their extensive knowledge. Among the groups providing information to the committee were the American Association of Colleges of Nursing, the American Dental Association, the American Medical Association, the American Psychological Association, the American Psychological Society, the Association for Health Services Research, the Association of American Medical Colleges, the Association of American Dental Schools, the Association of American Universities, the American Society for Cell Biology, the Council of Graduate Schools, and the Federation of American Societies for Experimental Biology.

Much information in this report is drawn from national surveys of doctoral scientists conducted under the direction of the National Science Foundation, with funding from a number of federal agencies, including the National Institutes of Health. The use of these data, of course, does not imply National Science Foundation endorsement of our research methods or conclusions.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution

in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report: Ralph M. Garruto, State University of New York at Binghamton; Ira Herskowitz, University of California, San Francisco; Lyle V. Jones, University of North Carolina, Chapel Hill; William J. Koopman, University of Alabama at Birmingham; Georgine M. Pion, Vanderbilt University; Samuel H. Preston, University of Pennsylvania; Shirley M. Tilghman, Princeton University; Jean D. Wilson, University of Texas Southwestern Medical Center; and Tadataka Yamada, SmithKline Beecham Corporation. While these reviewers provided constructive comments and suggestions, it must be emphasized that responsibility for the final content of this report rests entirely with the authoring committee and the institution.

The National Research Council staff members who contributed to this study are too numerous to acknowledge in a brief preface. We are especially indebted to Rodolfo Bulatao for the tirelessness and good grace with which he carried out the demographic analyses and drafted Appendix D of this report. James Voytuk ably generated volumes of data on behalf of the committee and patiently lent his expertise to their interpretation. Julie Parker, Edvin Hernandez, Peggy Petrochenkov, and Shirel Smith all cheerfully dedicated long hours to the preparation and production of this report.

Finally, a few words about Jennifer Sutton, the study director. The committee knows well (and I far more) that this report is in very large part attributable to her competence, thoughtfulness, seemingly inexhaustible energy, good humor, and tireless and effective management of the obstacles that arose, and warm and generous relations with the many on whom we called.

Howard Hiatt  
*Chair*

# Contents

<b>EXECUTIVE SUMMARY</b> .....	1
<b>1 INTRODUCTION</b> .....	4
Origins of the National Research Service Award Program, 5	
From 1975 to 1994: The First Ten Studies, 7	
Changes in the National Research Service Award Program, 9	
A Portrait of Research Training Today, 10	
Recent Developments in Research Training, 13	
The Current Study, 16	
<b>2 BASIC BIOMEDICAL SCIENTISTS</b> .....	18
Defining the Workforce, 18	
A Portrait of the Workforce, 18	
Trends in the Education of Basic Biomedical Scientists, 19	
Trends in Employment, 21	
The Role of Physicians in the Workforce, 23	
The Changing Role of the National Research Service Award Program, 24	
Implications and Recommendations, 28	
<b>3 BEHAVIORAL AND SOCIAL SCIENTISTS</b> .....	31
Defining the Workforce, 31	
A Portrait of the Workforce, 32	
Trends in the Education of Behavioral and Social Scientists, 33	
Trends in Employment, 35	
The Changing Role of the National Research Service Award Program, 37	
Implications and Recommendations, 39	
<b>4 CLINICAL SCIENTISTS</b> .....	42
Identifying the Workforce, 42	
Defining Clinical Research and the Clinical Research Workforce, 43	



Gauging the Size and Features of the Workforce, 44	
The Economics of Clinical Research, 45	
The Changing Role of the National Research Service Award Program, 47	
Implications and Recommendations, 51	

## 5 CROSSCUTTING ISSUES IN RESEARCH TRAINING . . . . . 53

Developing Research Workforce that Reflects the Nation and Addresses Its Health Needs, 53	
The National Research Service Award Program and Other Forms of Research Training Support, 55	
Setting Stipends and Other Compensation, 57	
The Training of Foreign Students and Fellows, 58	
Implications and Recommendations, 60	

## APPENDIXES

A National Research Service Award Institutional Training Grants and Fellowships . . . . .	65
B Committee on National Needs for Biomedical and Behavioral Scientists . . . . .	66
C Public Comment on the National Research Service Award Program . . . . .	69
D Demographic Projections of the Ph.D. Workforce in Biomedical and Behavioral Research, 1995-2005 . . . . .	72
E Classification of Ph.D. Fields . . . . .	99
F Personal Statement Concerning Research Training in the Behavioral and Social Sciences, John F. Kihlstrom . . . . .	101
G Supplementary Tables . . . . .	109

## FIGURES, TABLES, AND BOXES

### Figures

2-1	Gender Composition of the Basic Biomedical Workforce, 19
2-2	Ph.D.s Awarded in the Basic Biomedical Sciences in the United States by Gender, 20
2-3	Ph.D.s Awarded in the Basic Biomedical Sciences in the United States by Citizenship, 20
2-4	Employment of Basic Biomedical Scientists by Sector, 21
2-5	Employment of Basic Biomedical Scientists in Academia, 22
2-6	Trends in Graduate Students' Primary Source of Support in the Biomedical Sciences, 25
2-7	Selected Career Outcomes of Basic Biomedical Ph.D. Recipients from 1981 to 1992 by Nature of Support, 28
3-1	Growth in the Behavioral and Social Science Workforce and the Basic Biomedical Workforce, 32
3-2	Trends in the Composition of the Behavioral and Social Science Workforce, 33
3-3	Ph.D.s Awarded in the Behavioral and Social Sciences in the United States, 34
3-4	Ph.D.s Awarded in the Behavioral and Social Sciences in the United States by Gender, 34
3-5	Employment of Behavioral and Social Scientists by Sector, 36
3-6	Employment of Behavioral and Social Scientists in Academia, 36
3-7	Trends in Graduate Students' Primary Source of Support in the Behavioral and Social Sciences, 38
4-1	Trends in the Composition of the Clinical Research Workforce, 45
4-2	Students Receiving Various Types of Research Training During Medical School, 47
4-3	Physicians in Postdoctoral NRSA Training, 48
4-4	Recipients of Mentored Career Development Awards by Degree Type, 48

- 5-1 NRSA Stipends for Graduate Students and First-Year Postdoctorates, Actual and Adjusted for Inflation, 59
- D-1 The Potential Ph.D. Workforce of Biomedical and Behavioral Scientists, 73
- D-2 Age Distribution of Potential Workforce in 1995 by Field and Gender (in Two-Year Age Groups), 75
- D-3 New Ph.D. Graduates by Field and Gender, 1960-96, 76
- D-4 Proportion of Noncitizens Among U.S. Ph.D. Graduates by Field and Visa Type, 1960-96, 77
- D-5 Proportion of Ph.D. Graduates in Each Age Group by Field and Gender: 1990-96 Averages, 78
- D-6 Estimated Annual Ph.D. Immigrants, by Period, Field, and Gender, 80
- D-7 Biennial Shifts Between Science and Nonscience Jobs by Age Group: Biomedical Scientists, 1985-95 Averages, 83
- D-8 Biennial Shifts Between Science and Nonscience Jobs by Age Group: Behavioral Scientists, 1985-95 Averages, 83
- D-9 Proportion Retiring in Two Years Among Those Employed in Science by Age, Field, and Gender: 1985-95 Averages, 84
- D-10 Workforce Projections with Varying Numbers of Graduates: Biomedical and Behavioral Scientists, 1985-2005, 85
- D-11 Reported and Projected Workforce by Employment Status and Ph.D.s Outside Science: Biomedical Scientists, 1985-2005, 86
- D-12 Reported and Projected Workforce by Employment Status and Ph.D.s Outside Science: Behavioral Scientists, 1985-2005, 87
- D-13 Reported and Projected Age Distribution of Workforce: Biomedical Scientists, 1985-2005, 88
- D-14 Reported and Projected Age Distribution of Workforce: Behavioral Scientists, 1985-2005, 89
- D-15 Entries and Exits as a Proportion of the Workforce by Field and Gender, 2000, 90
- D-16 Reported Graduates and Alternative Projections: Biomedical Scientists, 1985-2005, 92
- D-17 Reported Graduates and Alternative Projections: Behavioral Scientists, 1985-2005, 93
- D-18 Reported and Projected Graduates and Limits Set by Enrollment Lagged Six Years: Biomedical Scientists, 1986-2005, 94
- D-19 Reported and Projected Graduates and Limits Set by Enrollment Lagged Six Years: Behavioral Scientists, 1994-2005, 95

## Tables

- 1-1 Distribution of Full-Time NRSA Trainee and Fellow Positions, Fiscal Year 1998, 11
- 1-2 Training-Related Activities of the NIH, 12
- 2-1 Comparison of the Average Benefits Provided to NRSA Recipients and NIH-Supported Graduate Research Assistants, Fiscal Year 1999, 26
- 4-1 NIH and AHRQ Competing Awards by Type of Research and Degree of Investigator, Fiscal Year 1997, 43
- 4-2 Ph.D.s Receiving NIH Awards for Clinical Research, by Field of Degree, 1988, 43
- 4-3 Medical School Debt Reported by 1997 Graduates, 46
- 5-1 Racial and Ethnic Distribution of Selected Populations, 1997 (percent), 54
- 5-2 NRSA Stipends, Fiscal Year 1999, 57
- 5-3 Ph.D.s Awarded to Temporary-Visa Holders, 59
- D-1 Ph.D. Workforce by Employment Status, Plus Those Outside Science and Retired, by Major Field and Gender, 1995, 74

- D-2 Immigrant Ph.D.s by Employment Status, Field, and Gender, 1995, 79
- D-3 Initial Employment Status and Status Two Years Later, Pooled 1985-95 Data (percent), 82
- D-4 Projected Ph.D. Workforce and Ph.D.s Outside Science, Assuming Medium Trend in Graduates and Constant Immigration, 1995-2005, 86
- D-5 Projected Ph.D. Workforce and Ph.D.s Outside Science, Assuming High Trend in Graduates and Rising Immigration, 1995-2005, 90
- D-6 Projected Ph.D. Workforce and Ph.D.s Outside Science, Assuming Low Trend in Graduates and No Immigration, 1995-2005, 91
- D-7 Graduates Needed to Maintain a Constant Workforce or a Workforce with Fixed Growth, by Field and Gender, 1996-2005, 91
  
- F-1 Sources of Predoctoral NRSA Research Training Support for 1995 Ph.D. Recipients in the Biomedical and Behavioral Sciences, 104
  
- G-1 Demographic Characteristics of Ph.D. Recipients in the Basic Biomedical Sciences, 110
- G-2 Demographic Characteristics of Ph.D. Recipients in the Behavioral and Social Sciences, 112
- G-3 Demographic Characteristics of Ph.D. Recipients in the Clinical Sciences, 114
- G-4 Characteristics of the Science and Engineering Workforce in the Basic Biomedical Sciences, 116
- G-5 Characteristics of the Science and Engineering Workforce in the Behavioral and Social Sciences, 117
- G-6 Characteristics of the Science and Engineering Workforce in the Clinical Sciences, 118
- G-7 Primary Form of Financial Support for Graduate Students in the Basic Biomedical Sciences, 119
- G-8 Primary Source of Financial Support for Graduate Students in the Behavioral and Social Sciences, 120

**Box**

- 1-1 National Research Service Award Act of 1974 (P.L. 93-348), 7