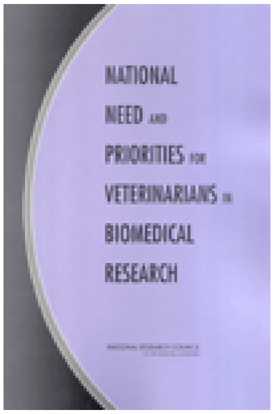

National Need and Priorities for Veterinarians in Biomedical Research

Committee on Increasing Veterinary Involvement in Biomedical Research, National Research Council

ISBN: 0-309-52772-4, 102 pages, 6 x 9, (2004)

NATIONAL NEED AND PRIORITIES FOR VETERINARIANS IN BIOMEDICAL RESEARCH

Committee on Increasing Veterinary Involvement in Biomedical Research
Institute for Laboratory Animal Research
Division of Earth and Life Studies
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, DC
www.nap.edu

THE NATIONAL ACADEMIES PRESS 500 Fifth Street, N.W. Washington, DC 20001

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This study was supported by the American College for Laboratory Animal Medicine, the American Society for Pharmacology and Experimental Therapeutics, the American Veterinary Medical Association, GlaxoSmithKline, Merck and Co., Pfizer, Inc, and Contract No. N01-OD-4-2139, Task Order 87 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 author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

International Standard Book Number 0-309-09083-0 (Book)
International Standard Book Number 0-309-52772-4 (PDF)

Additional copies of this report are available from the National Academies Press, 500 Fifth Street, NW, Washington, DC 20001; (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area); Internet, http://www.nap.edu.

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Preface

The Committee on Increasing Veterinary Involvement in Biomedical Research was commissioned to examine a highly relevant issue facing the biomedical research community both in academia and industry: How can more veterinarians be prepared for careers in biomedical research?

A report written by Weigler et al. in 1997 concluded that the marketplace for veterinarians with specialty training in laboratory animal medicine had reached a steady state by 1995, when the national supply of and demand for veterinarians with this expertise were closely aligned (Weigler et al., 1997). Their analysis suggested that the balance of supply and demand would not change in any substantive way in the years 1995-2005. However, their report could not predict several pivotal issues that changed the need for veterinarians trained for careers in biomedical research. One of the most compelling was the dramatic increase in the use of genetically engineered animals, particularly mice. Such use has escalated during the last 5 years, further fueled by the publication of the mouse and human genomes. It has been estimated that 60 million genetically engineered mice may be needed to study every gene in the mouse genome (Knight and Abbott, 2002). The rapid increase in rodent-based biomedical research is accompanied by the need to monitor and prevent the introduction of infectious agents into established rodent colonies and biologic products that are shipped in increasing numbers nationally and internationally.

Translational research, in which knowledge derived from molecular and cellular biology is being applied in studies involving systems and integrative biology, is burgeoning. Those applications rely heavily on the use of animals, particularly rodents. Indeed, between 1990 and 2002, there was a 60% increase in the number of competitive grants that utilize animals.

All those factors in the aggregate have affected the need for veterinarians with specialty training in biomedical research, and the supply of veterinarians with this training has not kept pace with demand. Compounding the increased need for veterinary scientists' involvement in biomedical research is the ever-increasing requirement of veterinarian oversight of compliance with state and federal regulations regarding animal-based research. This report is intended to document the need for veterinarians with specialty training and to recommend ways to alleviate the veterinary personnel shortage.

The committee acknowledges the assistance and advice offered by various people who provided their time, professional experience, and insight. On October 4, 2002, several individuals with acknowledged expertise in academic veterinary medicine or biomedical research and in training of veterinarians in biomedical research delivered formal presentations to the committee and other interested parties who attended the open session of the committee's first scheduled meeting. The committee appreciates their thoughtful and informative presentations.

Linda Cork, Department of Comparative Medicine, School of Medicine, Stanford University, Stanford, California
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We also acknowledge the financial support of the following institutions: The American College for Laboratory Animal Medicine; the American Society for Pharmacology and Experimental Therapeutics; the American Veterinary Medical Association; GlaxoSmithKline; Merck and Co., Inc.; NIH; and Pfizer, Inc. Representatives of some of those organizations provided critical data for the committee:

Lynn Anderson, Merck and Co., Inc., Rahway, New Jersey
Nelson Garnett, Office of Laboratory Animal Welfare, NIH, Bethesda, Maryland
Franziska Grieder, National Center for Research Resources, NIH, Bethesda, Maryland

John Strandberg, National Center for Research Resources, NIH, Bethesda, Maryland
Mary Ann Vasbinder, GlaxoSmithKline, Research Triangle Park, North Carolina

Two other colleagues, **Ben Weigler** and **Leslie Colby**, were extremely helpful in providing survey data that they had gathered and tabulated on laboratory animal veterinary personnel needs.

This report has been reviewed in draft form by individuals chosen for their diverse perspective 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 its 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 review of this report:

William J. Heuston, Department of Family Medicine, Medical University of South Carolina, Charleston, South Carolina
Robert O. Jacoby, School of Medicine, Yale University, New Haven, Connecticut
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Janice D. Wagner, Department of Comparative Medicine, Bowman Gray School of Medicine, Wake Forest University, Winston-Salem, North Carolina

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by:

Harold J. Fallon, University of Alabama, School of Medicine (*emeritus*), Birmingham, Alabama
William R. Brinkley, Baylor College of Medicine, Houston, Texas

Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

I extend my deep appreciation to the committee members, staff, and those who presented information at our initial committee meeting. Members of the committee devoted considerable time and effort in deliberating on and analyzing the data included in this report. I also want to thank the reviewers for their timely and thoughtful comments; their insightful comments enhanced the value of this report. I particularly want to acknowledge the considerable skills and tireless efforts of Jennifer Obernier in assembling and composing the committee report. Kathleen Beil provided logistical support by arranging travel and lodging throughout, which made the committee's tasks easier. Thanks are also extended to Marsha Barrett and Stephanie Thuemmler, who provided project support and assisted in generating the graphics in the report, and to Norman Grossblatt and Susan Vaupel, who edited the manuscript. And I also thank Joanne Zurlo and Ralph Dell for providing counsel to the committee during its deliberations.

James Fox, *Chair*
Committee on Increasing Veterinary
Involvement in Biomedical Research

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Executive Summary

PURPOSE AND SCOPE OF THIS REPORT

The biomedical research enterprise has expanded rapidly since 1995 (NRC, 2000), and it is possible that research activity, particularly in neuroscience and transgenic research, which relies heavily on the use of laboratory animals, may have outpaced the supply of veterinarians trained in specialties related to biomedical research. With biomedical research priorities shifting from basic molecular and cellular research to translational research, the importance of animal models and therefore veterinarians skilled in comparative medicine has increased. Bioterrorism has also brought new priorities to bear, in that most potential bioterrorism agents are zoonotic and key to any research team managing animals with zoonotic diseases is the veterinarian. Such anecdotal evidence suggests there is a need for more veterinarians to participate in or support biomedical research, which has prompted a variety of organizations (National Institutes of Health (NIH), American College of Laboratory Animal Medicine (ACLAM), the American Society for Pharmacology and Experimental Therapeutics, the American Veterinary Medical Association (AVMA), GlaxoSmithKline, Merck and Co., and Pfizer, Inc.) to fund a study to investigate what could be done to resolve this perceived shortage of veterinarians in biomedical research.

The Committee on Increasing Veterinary Involvement in Biomedical Research was convened under the auspices of the Institute for Laboratory

Animal Research to examine the question: How can more veterinarians* be prepared for careers in biomedical research? The committee was asked to develop strategies for recruiting more veterinarians into postgraduate training programs in specialties that can be applied to the biomedical research endeavor.

LIMITATIONS OF THE CURRENT STUDY

In order to develop a comprehensive strategy for recruiting more comparative medicine veterinarians into careers in biomedical research, the authoring committee determined that a detailed examination of the current comparative medicine veterinary workforce was needed, as were projections on the future of this workforce. This type of quantitative examination requires extensive demographic information on the workforce. Unfortunately, the authoring committee found that the majority of the demographic information they sought does not exist. The comparative medicine veterinary workforce is an extremely diverse workforce, with a wide variety of educational and training experiences as well as many different career pathways. Compounding this is the fact that comparative medicine veterinarians comprise a very small portion of any professional categorization, and there is little impetus for any one professional organization or society to expend resources on the types of detailed demographic surveys that exist for other doctoral professionals such as doctors of medicine (MDs), doctors of philosophy (PhDs), and engineers. The committee therefore reaffirms the recommendation of the 1982 National Research Council (NRC) report *Specialized Veterinary Manpower Needs Through 1990* (see Appendix A) that:

> the Association of American Veterinary Medical Colleges (AAVMC) and the American Veterinary Medical Association (AVMA) should expand their data-gathering efforts to collect more information on the veterinary manpower used by the non-private-practice sector. A comprehensive survey of this sector should be conducted in the near future to assist in the development of predictions of employment in areas other than private practice.

---

*Hereafter referred to as comparative medicine veterinarians. Comparative medicine veterinarians are those with postgraduate research and/or clinical training that is applied to the endeavor of biomedical research. This training can be in one of many specialty areas including but not limited to: laboratory animal medicine, comparative medicine, comparative pathology, genetics, physiology, microbiology, pharmacology, and toxicology.

For the AVMA in particular, this does not require the creation of new demographic survey methodology as the AVMA could utilize its current methodology for surveying their membership and recent graduates of veterinary medical schools and extend the survey to gather demographic information on the comparative medicine veterinary workforce.

Nevertheless, the committee was charged with developing a set of recommendations for recruiting more veterinarians into careers in biomedical research. The committee therefore relied heavily on the small amount of demographic information available on specific subpopulations of the workforce, such as laboratory animal veterinarians, comparative pathologists, and principal investigators with a doctor of veterinary medicine (DVM) degree. The committee's information gathering and deliberations revealed that, though difficult to quantify, there were many indications that there is a shortage of veterinarians participating at all levels in the biomedical research enterprise. Some of the committee's major findings regarding the adequacy of the comparative medicine veterinary workforce include:

- From 1995 through 2002, the number of NIH-funded competitive grants utilizing animals increased by 31.7%. There were approximately 1,300 more competitive grants utilizing animals in 2002 than in 1995.
- Approximately 85% of animals utilized in biomedical research are rats and mice. In 1998, it was estimated that 23 million rats and mice were utilized in biomedical research. It is predicted that mouse use alone will continue to increase by 10% to 20% annually over the decade 2000-2010.
- From 1997 through 2002, the number of active diplomates with board certification in laboratory animal medicine increased by less than 3% annually. This resulted in a total increase from 1997-2002 of 15%.
- Currently, there are an estimated 1,608 research institutions in the US that are USDA-registered and/or hold NIH assurances indicating those institutions utilize animals in research programs. In contrast, only 666 actively employed individuals held board certification in laboratory animal medicine in 2002.
- The number of individuals who completed residency training in laboratory animal medicine was 25% lower in 2002 than 1996.
- The number of active laboratory animal medicine residency programs was the same in 1995 as it was in 2002. Of the 32 currently active programs, 9 of these programs did not have anyone complete a residency from 1996 to 2002.
- There is an estimated deficit of 67 clinical veterinary pathologists in the US and Canada in 2002. By 2007, this deficit is estimated to increase to 336 positions.

- In 2001, RO1 grants awarded to principal investigators with a DVM degree comprised only 4.7% of all the NIH-funded competitive grants utilizing animals.
- From 1994 to 2002, the number of National Center for Research Resources (NCRR)-funded T32 training grants has remained relatively unchanged (median number of programs is 14, range 13-16). In addition, some National Research Service Award (NSRA):Institutional Training Grant (T32)-funded programs do not utilize all the training slots for which they receive funding.

RECOMMENDATIONS

After analyzing available data on the demographics of the comparative medicine veterinary workforce and the postgraduate training of comparative medicine veterinarians, the committee developed a series of recommendations to increase the number of veterinarians participating in biomedical research. These recommendations reflect the concept that postgraduate training is the key to increasing the supply of veterinarians to the comparative medicine workforce. The committee found that while funding is a problem for some institutions, particularly those with residency programs, there is a distinct lack of qualified applicants for all types of postgraduate training programs. This is due to several factors, including the financial barriers caused by excessive educational debt. However, in the committee's opinion, one of the key factors negatively impacting the supply of comparative medicine veterinarians is the lack of commitment by veterinary medical schools and institutions that offer postgraduate training programs to prepare and train veterinary students and postgraduates for veterinary careers other than private clinical practice. The committee has developed a series of recommendations to address this problem, though changing the attitudes of faculty, policy-makers, and administrators will be a long-term process. Therefore, the committee also developed additional recommendations to deal with the shortage of comparative medicine veterinarians in the short term, including retraining veterinarians dissatisfied with careers in private clinical practice.

- **Acquaint Students with Opportunities in Comparative Medicine Throughout Veterinary School**

To increase the supply of applicants to veterinary schools and postgraduate training programs who have a sincere interest in comparative medicine, the comparative medicine veterinary community (as individuals, professional societies, and academic institutions) must actively work to educate undergraduate and veterinary school students about the role of veterinarians in biomedical research, the training necessary to achieve these careers, and the benefits associated with careers in comparative medicine. All comparative medicine veterinarians should actively seek out and mentor students with an aptitude for and interest in comparative medicine and biomedical research.

To further nurture student interest in careers in biomedical research, veterinary schools are encouraged to establish summer externship programs and year-long research programs that can be supported through the NRSA: Professional Student Short-term Research Training Grant (T35) and T32 NIH award mechanisms, as well as through institutional funding and partnerships with corporate sponsors.

- **Increase Veterinary School Recruitment of Applicants with Interest or Experience in Comparative Medicine**

Veterinary schools should aggressively seek applicants with an interest in comparative medicine, and admissions committees should be encouraged to select applicants with interests outside private clinical practice. In addition, residency programs and research training programs should actively recruit interested private practice veterinarians to retrain for careers in comparative medicine.

- **Effect Change in Veterinary School Curriculums**

To introduce a wider population of veterinary medical students to the field of comparative medicine, all veterinary schools should offer at least elective courses in laboratory animal medicine, and more veterinary schools should require coursework in laboratory animal medicine.

- **Address Financial Barriers to Postgraduate Training in Comparative Medicine**

To address concerns about the large debt burden that graduates of veterinary colleges face, a debt-repayment initiative similar to the NIH Clinical Research Loan Repayment Program authorized by the Clinical Research Enhancement Act (H.R. 2498) should be initiated.

- **Increase the Number of Veterinarians in Roles Supporting Biomedical Research**

To increase the number of individuals with an interest in clinical careers in biomedical research, residency programs should aggressively recruit applicants through veterinary student clubs, national meetings, career days, etc. In addition, the American College of Laboratory Animal Medicine (ACLAM) and the American College of Veterinary Pathologists (ACVP) should facilitate the registration of their respective residency programs with the Veterinary Internship and Residency Matching Program (VIRMP).

- **Increase the Number of Veterinarians Serving as Principal Investigators**

Each awardee institution should take full advantage of their T32 award by utilizing all of the trainee positions for which they receive funding (between 4 and 6 trainee positions per year). In addition, if the current T32 program becomes maximally utilized, NIH should consider increasing funding to this program to accommodate additional awardee institutions. The T32 award requirement that all individuals complete one year of clinical training is creating unnecessary barriers for veterinary graduates wanting to enter training programs immediately after graduation. This requirement should be removed from T32 granting stipulations. Research institutions and schools of veterinary medicine should also encourage postgraduate veterinary trainees to apply for NRSA:Individual Postdoctoral Fellowship (F32) awards and K awards and should actively provide the support necessary for young veterinary researchers to compete successfully for these awards. Veterinary schools should also seek to strengthen their dual-degree (DVM-PhD) programs through the NIH-funded Medical Scientist Training Program (MSTP) mechanism.

1

Introduction

MISSION OF THE VETERINARY PROFESSION

The veterinary profession is founded on service to society and advancement of medical knowledge; therefore, the profession as a whole must periodically reassess its role in society and the emphasis of veterinary medical education and its specializations. Historically, the profession has adapted successfully to the changing needs of society. Equine medicine was the dominant focus of the veterinary profession during the 19th century; as epizootics in other agricultural animals erupted and the understanding of germ theory was acquired and put into practice, agricultural medicine dominated the profession during the early 20th century. Then, as dogs and cats became more common in American households during the second half of the 20th century, the profession once again responded to society's particular needs for veterinary services (Eyre, 2002). Currently, some 61% of veterinarians are involved in a predominantly or exclusively small-animal clinical practice, and 84% of the veterinary workforce is involved in private clinical practice (AVMA, 2001).

While companion and agricultural animal care has most recently dominated the veterinary profession, veterinarians make significant contributions in other fields, including biomedical research (defined as research contributing to understanding of human physiology and pathology, including behavioral and clinical research). Veterinarians participate in biomedical research through the utilization of their specialized training in animal biology and medicine to model human physiology and disease.

VETERINARIANS AS PRINCIPAL INVESTIGATORS

Some veterinarians, referred to as principal investigators, participate in biomedical research by directly initiating and leading research programs at academic and corporate research institutions. Veterinarians also contribute to research programs as co-investigators, research scientists, and technical advisors. In fact, many of the first discoveries in modern biomedical research originated from veterinarians investigating diseases common to both humans and animals, such as blood-borne parasitic diseases and leukemia. These discoveries have led to major advancements in the understanding and treatment of human and animal diseases, and have occurred in every major field of biomedical research.

Virology and Microbiology

In 1898, the veterinarians Loeffler and Frosch were the first to discover an animal virus when they demonstrated that a particle smaller than a bacterium could cause foot-and-mouth disease (Brown, 2003). Ten years later Danish veterinarians Ellerman and Bang (1908) provided the first evidence that some leukemias are caused by viruses. William Hadlow, a Public Health Service veterinarian, discovered histologic similarities between scrapie and kuru, leading to the breakthrough research on prion disease (Eklund and Hadlow, 1973). Smith and Kilborne (a veterinarian) (1893) were the first to demonstrate that an insect could transmit disease. Their research into identifying the arthropod vector for Texas fever contributed to the discovery that mosquitoes transmitted malaria and yellow fever. Veterinary medical scientists continued to make significant contributions in microbiology, especially in the field of retrovirology where the feline retroviruses were investigated by William and Oswald Jarrett, Neils Pedersen, Charles Rickard, Max Essex, William Hardy, and Edward Hoover; chicken retroviruses by Peter Biggs; and cattle leukemia viruses by Carl Olson, Martin van Der Maartin, and Arsene Burny, all veterinarians (Gallo, 1991). Theilen, Essex, and many other veterinarians were among the first to study simian immunodeficiency. This important animal model continues to advance our knowledge of human acquired immunodeficiency syndrome through studies led by the veterinary scientist A. A. Lackner and associates, among others (Veazey and Lackner, 1998).

Veterinarians have been instrumental in elucidating the etiopathogenesis of many infectious (NRC, 1991) and non-infectious (Fox et al., 2001) diseases of laboratory animals, and they continue to make important contributions, such as the recent discovery of murine *Helicobacter* spp. and their role in disease (Fox et al., 2000). Others have contributed by defining the pathologic and clinical chemical changes seen in infectious and non-infectious diseases of laboratory animals (Percy and Barthold, 2001).

Cellular Physiology

Veterinarians have also advanced our understanding of cellular physiology. In 1922, a veterinarian named Schofield discovered that moldy hay caused hemorrhagic disease (Schofield, 1922). He went on to isolate the causative agent, dicoumerol, analogues of which are used to treat thromboses in humans. At the other end of this disease spectrum, veterinarian Jean Dodds characterized the clinical and hematologic abnormalities in several spontaneous hemorrhagic diseases of dogs (Dodds, 1988). These investigations have continued under the auspicious work of James Catalfamo and Margory Brooks, a veterinarian, and include the molecular and genetic characterization of many inherited hemorrhagic diseases in dogs, which serve to model illnesses of humans and in which gene therapy trials are under way (Gu et al., 1999).

Immunology

The physician-veterinarian team of Miller and Mitchell, using laboratory mice, was the first to demonstrate the importance of thymic-derived lymphocytes in providing "help" to bone marrow-derived cells in the production of antibody (Miller and Mitchell, 1969). Veterinarian Morten Simonsen was the first to discover graft vs. host disease in chicken embryos (Simonsen, 1957). British veterinarian Robin Coombs developed the antiglobulin test, which bears his name, now used in the diagnosis of autoimmune hemolytic anemia in humans and animals (Coombs et al., 1945). And in 1996, veterinarian Peter Doherty, won the Nobel Prize in physiology or medicine for discovering that the immune system is capable of dual recognition; that is, it can recognize foreign and endogenous antigens (Zinkernagel and Doherty, 1974a,b).

Public Health

Public health and safety have also benefited from the involvement of veterinarians. D. E. Salmon, founding director of the Bureau of Animal Industry, instituted significant public health policies, including a nationwide system for meat inspection and quarantine requirement for imported livestock, and for the inspection of exported cattle and the ships on which they are transported. Veterinarians are also on the front lines of the war on biological terrorism, as the majority of biological terror agents are zoonotic diseases. Of special note in this regard, Frederick Murphy, a veterinarian, was the first to demonstrate the morphology of Ebola virus (Murphy, 1971), and Nancy and Gerald Jaax, both veterinarians, were the first to describe an outbreak of Ebola virus in monkeys in the United States

(Geisbert et al., 1992). Veterinarian Tracy McNamara was the first to identify West Nile virus in North America (Hansen et al., 2001).

Cutting Edge Research and Innovations

Veterinarians continue to make significant contributions in virtually every area of biomedical research. Ralph Brinster is credited with the pioneering discoveries that allowed for the production of transgenic animals. In addition, he is among the first to successfully transplant germ cells and appreciate the role of stem cells and the microenvironment of this new area of research (Brinster and Avarbock, 1994). Gus Aguirre and Greg Acland, both veterinarians, have published the clinical, molecular, and genetic abnormalities in dogs with inherited retinal diseases and were the first to restore vision to a blind dog by gene therapy (Acland et al., 2001). Veterinarian John Sundberg has contributed greatly to our understanding of the molecular and pathological basis of inherited skin diseases (Sundberg and King, 2000).

VETERINARIANS IN ROLES THAT SUPPORT BIOMEDICAL RESEARCH

Veterinarians also participate in biomedical research in a supportive role as the key individual who oversees the veterinary medicine program at research institutions and who, by law, has direct or delegated authority for activities involving animals (9 CFR Sec 1.1). In this capacity, these individuals are known as attending veterinarians. Attending veterinarians not only directly provide medical care for research animals (also referred to as laboratory animals), but they also are a federally-mandated member of animal care and use committees. Using their specialized knowledge base, they work collaboratively with the committee to establish standards and provide ongoing evaluations of the care, treatment, housing, and use of all animals utilized at the research institution. In addition, they provide technical instruction to researchers, collaborate and provide technical advice on experiments utilizing animals, and ensure animal well-being. Large research institutions may also employ additional veterinarians to assist with the veterinary medicine program. These individuals are usually referred to as staff veterinarians. Both attending and staff veterinarians have specialized training or experience in laboratory animal medicine, and the preferred standard of training experience is board certification in laboratory animal medicine through the American College of Laboratory Animal Medicine (ACLAM).

Paramount to successful research is information on selection of animal models, animal sources, animal anatomy, physiology, and care and management. This information is comprehensively provided by attending and staff veterinarians as well as veterinarians with training in other specialties such as pathology. Their expertise allows them to train and otherwise support investigators in the performance of animal-based experimental techniques, which include providing surgical expertise, perioperative care, anesthesia and analgesia, and approved euthanasia methods. The needed training extends past the level of the investigator to animal care providers, to animal care and use committee members, and to the institutional administration charged with providing the resources to support animal research. These veterinary professionals both protect and promote research through their knowledgeable understanding and implementation of federally required animal care and use policies, and through educational outreach in the role of veterinary caregiver and research facilitator with the lay community, media, and regulatory agencies.

In summary, the contributions made by trained comparative medicine veterinarians are critical to the successful execution of biomedical research. These veterinarians have the knowledge base to construct policies and procedures that optimize animal husbandry and environments, which in turn affects the health status and breeding capabilities of research animals. Management that promotes optimal animal health congruent with maximizing an institution's resources requires the specialized expertise that veterinarians, particularly those specializing in laboratory animal medicine, possess. As pointed out during the National Institutes of Health (NIH) reauthorization hearings (Cassell and McCauley, 1996), "individuals well trained in laboratory animal medicine (clinician-scientists) are essential to ensure the highest quality of laboratory animal care as well as to achieve the maximum benefit from research using animals."

SCOPE OF THIS STUDY

Throughout the last century, the biomedical research workforce has steadily increased. After World War II, the US government became a major sponsor of scientific research leading to the dramatic expansion of publicly funded biomedical research (NRC, 1985). During the same time period, the discovery of antibiotics led to a large expansion in pharmaceutical and privately funded research (Rowan and Loew, 2001) that has continued into the 21st century. The research-scientist workforce is composed primarily of individuals holding PhDs (NRC, 2000); however, other doctorates, such as MDs and DVMs, also play important and unique roles in the biomedical research enterprise, and special attention to these subpopulations is necessary. In 2000, a NRC report highlighted the decline in MDs identifying research as their primary professional activity and recommended that efforts to train and retrain physicians be intensified until the clinical biomedical research workforce includes substantially more MDs (NRC, 2000). Similarly, anecdotal evidence now suggests that the increased demand for laboratory animals, increased regulatory requirements, and increased focus on translational research have led to an increased need for veterinarians in biomedical research workforce (Gaertner, 2001; Jacoby, 2000a,b; Schub, 2001). In fact, the importance of translational research is being recognized at the highest levels of NIH. Dr. Elias Zerhouni, Director of NIH, identified new priorities for healthcare research in the United States while speaking at the Steps to a Healthier US Summit in April of 2003, including the ". . . need to more quickly translate our discoveries into practice." Dr. Zerhouni indicated a new emphasis at NIH on translational research, the process where information gleaned from molecular, cellular, and animal research requires interpretation and further study by researchers (in particular veterinarians) so the information can be translated into human therapies. This process relies heavily on animal research and on comparative medicine veterinarians, and suggests that societal needs for veterinarians are changing and the veterinary profession must adapt to continue to fulfill its mission.

In response to these changes, the Institute for Laboratory Animal Research (ILAR) Committee for Increasing Veterinary Involvement in Biomedical Research was commissioned to examine the question: How can more veterinarians be prepared for careers in laboratory animal medicine, comparative medicine, and comparative pathology? This statement of task presupposes that the current workforce is inadequate, based on the experiences of the sponsors, NIH (Office for Laboratory Animal Welfare and National Center for Research Resources), ACLAM, the American Society for Pharmacology and Experimental Therapeutics, the American Veterinary Medical Association (AVMA), GlaxoSmithKline, Merck and Co., and Pfizer, Inc. After hearing testimony from sponsors, veterinary leaders in biomedical research, and the public, the authoring committee concluded that the development of a comprehensive strategy for recruiting more comparative medicine veterinarians into postgraduate training programs required thorough examination of the assertion that more veterinarians are needed in biomedical research. This examination entailed three steps: (1) defining the population of veterinarians that are involved in biomedical research; (2) assessing the adequacy of the current workforce; and (3) projecting the future of this workforce. The remainder of this chapter is devoted to the committee's efforts to define the population, while the analysis of the adequacy of the current workforce appears in Chapter 2, and the projections of the future workforce are described in Chapter 3. These analyses then enabled the committee to develop recommendations, covered at length in Chapter 4.

DEFINING THE POPULATION OF VETERINARIANS INVOLVED IN BIOMEDICAL RESEARCH

When defining the population of veterinarians in biomedical research, the committee relied on public testimony, invited speakers, and their own professional experience and expertise in academic, corporate, and government research settings. It became apparent that veterinarians not only act as attending veterinarians and clinical practitioners of laboratory animal medicine, but they also participate in research in every manner that a PhD or MD would be involved: as a principal investigator, co-investigator, research scientist, or technical advisor.

While some veterinarians participate in the biomedical research endeavor successfully without benefit of specialized training, postgraduate training provides a necessary and preferred foundation of knowledge and experience for these veterinarians. The necessity of this training becomes apparent when the educational curriculum at veterinary schools is examined. For example, in a 2002 American Association of Veterinary Medical Colleges (AAVMC) survey of the top 27 NIH-funded veterinary medical programs, only six of 22 respondents required one or two courses in laboratory animal medicine (none required more), 13 offered electives (from one to six electives), and three offered no courses in laboratory animal medicine.

In an effort to unify the concept of the veterinarian participating in biomedical research, the authoring committee chose to identify this group of individuals as "comparative medicine veterinarians" and describes them as veterinarians who receive postgraduate research and/or clinical training that is applied to the endeavor of biomedical research. This training can be in one of many specialties areas including, but not limited to, laboratory animal medicine, comparative medicine, comparative pathology, genetics, physiology, microbiology, pharmacology, and toxicology. This definition emphasizes the importance of postgraduate training to the success of the comparative medicine veterinarian, but also acknowledges the diversity of experience, education, and responsibilities within this workforce.

In identifying the population of veterinarians included in this report, the authoring committee included individuals who participate in research directly relating to human disease and health. Because of the lack of a comprehensive database, this population has been restricted to individuals that participate in NIH-funded biomedical research or research at pharamceutical/biotechnical companies. For example, veterinarians involved in agricultural research were not included, nor were veterinarians participating in federal programs to ensure public health or safety, such as the US Department of Agriculture (USDA), Food and Drug Administration (FDA), or Centers for Disease Control and Prevention (CDC). It is important to point out that individuals with similar training can assume varied responsibilities. For example, the ACLAM/ASLAP salary survey (ACLAM/ASLAP, 2003) identifies laboratory animal veterinarians as clinical veterinarians (e.g., attending veterinarian), administrative staff (e.g., research animal resource program directors), faculty (e.g., principal investigators or co-investigators), and private consultants.

The authoring committee categorized comparative medicine veterinarians by their primary professional duty either as veterinarians participating directly in biomedical research or as veterinarians providing professional support for biomedical research. Many veterinarians whose primary duty is participating directly in biomedical research as principal investigators, co-investigators, research scientists, and technical consultants also have clinical duties as an attending or staff veterinarian, although the majority of their time is spent working on a research project. The other category of comparative medicine veterinarian is composed of those individuals whose primary professional duty is as an attending or staff veterinarian providing clinical services to the veterinary medicine program at a biomedical research institution. These individuals often contribute to specific research projects as technical advisors and even collaborators; however, the majority of their efforts are directed toward clinical and management aspects of the veterinary medicine program. Although these general categorizations are used throughout this report, it is important to understand that most comparative medicine veterinarians have professional duties in both categories, and that in many cases, this pull between various duties can be a source of professional frustration. During public testimony on the subject, it was apparent that many times faculty positions for veterinarians are contingent on a certain percentage of their time being given to clinical duties that support the institution's veterinary medicine program—a contingency to which few other PhD faculty are subject, although MD faculty are. Attending and staff veterinarians may be pulled between their desire to interact more directly in the research programs at their institution and the large amount of time required to manage the extensive regulatory aspects of an animal research facility.

2

Adequacy of the Current Comparative Medicine Veterinary Workforce

Ideally, an analysis of the adequacy of the current comparative medicine veterinary workforce would be based on information such as time necessary to fill open job positions, the percentage of veterinarians entering the workforce that achieves appropriate faculty, research, managerial, or administrative positions, and the employment rate of this workforce. Similar analyses have evaluated the PhD and MD workforces in biomedical research (NRC, 2000). These detailed analyses were possible because the PhD workforce is the subject of national surveys sponsored by the National Science Foundation, and information on the MD workforce is collected by the American Medical Association.

However, because the comparative medicine veterinary workforce encompasses individuals with different educational backgrounds, professional experiences, and career pathways, data sets describing the entire veterinary workforce in biomedical research are not available. It is therefore difficult to estimate the veterinary workforce, as was acknowledged in the NRC report *Addressing the Nation's Changing Needs for Biomedical and Behavioral Scientists* (NRC, 2000). The only unifying characteristics of the comparative medicine veterinary workforce are (1) that they have obtained a doctorate of veterinary medicine and (2) that they either directly perform biomedical research or support biomedical research in a professional capacity. While the AVMA membership would potentially include the veterinary workforce involved in biomedical research, this workforce is a very small minority of the membership (less than 1% of the AVMA membership in 2002 had board certification in laboratory animal medicine, and less than 2% had board certification in pathology), and demographic information specific to this subpopulation of veterinarians is not collected. Some professional societies, such as ACLAM and the American College of Veterinary Pathologists (ACVP), do obtain demographics of their membership to varying degrees; however, veterinarians who participate in biomedical research, with the exception of laboratory animal veterinarians, are generally following non-traditional career paths and there is little impetus among professional societies to investigate the demographics, supply, or demand for these individuals. For example, veterinarians participating in biomedical research as principal investigators or technical consultants are more likely to be affiliated with a professional research society (e.g., Society for Neuroscience) than a professional veterinary society.

The committee was able to identify some data on various subpopulations of comparative medicine veterinarians, such as individuals who have obtained board certification in laboratory animal medicine or pathology. However, the authoring committee was unable to find any usable data on some subpopulations, such as veterinarians who are co-investigators, research scientists, or technical consultants. This lack of usable information prevented the committee from performing a detailed, quantitative analysis of the current workforce. Because the authoring committee was not commissioned to survey the workforce, they were forced to rely heavily on data collected by professional societies and NIH on three subpopulations of the workforce: laboratory animal medicine veterinarians, veterinary pathologists, and veterinary principal investigators. Data available on these three subpopulations of workforce are presented in the following sections.

LABORATORY ANIMAL MEDICINE VETERINARY WORKFORCE

As described by ACLAM, the professional society that administers specialty certification, laboratory animal veterinarians are veterinary medical specialists who are experts in the humane, proper, and safe care and use of laboratory animals. The majority of laboratory animal medicine veterinarians (as identified by membership in the American Society for Laboratory Animal Practitioners [ASLAP] or ACLAM) identified themselves as administrative, management, or clinical staff involved in the management of laboratory animal facilities (Weigler and Huneke, 2003). These individuals, acting as attending veterinarians, staff veterinarians, and facility directors, oversee the care and use of laboratory animals in biomedical research institutions, such as universities, hospitals, and biotechnical and pharmaceutical companies. Most of these institutions are subject to the Animal Welfare Act (AWA), which is enforced by the USDA and applies to any research institution utilizing warm blooded animals other than birds, rats of the genus

Rattus, or mice of the genus *Mus*; and/or to the Public Health Service (PHS) Policy, which is enforced by NIH through its assurance program and which regulates any research institution receiving federal funding through the PHS. Both the AWA and PHS Policy require that each research institution have a veterinarian with training or experience in laboratory animal medicine responsible for the activities involving animals at the institution, often defined as attending veterinarians. These individuals are the most visible subpopulation of the comparative medicine veterinary workforce, and more information and data were available on this subpopulation of the workforce than on any other.

For these individuals, ACLAM board certification is considered the preferable standard of specialized training. ACLAM is the only US organization that establishes standards of education, training, experience, and expertise necessary to become qualified as a specialist in laboratory animal medicine and that recognizes achievement through board certification. Individuals who desire to sit for the certifying examination must have either 24 months of formal training in an ACLAM-accredited training program and a total of 4 years of training and experience; or, if they do not train in an ACLAM-accredited program, they must have 6 years of full-time experience in laboratory animal medicine. In addition to the training and experience requirements, a candidate must be the first author of a scientific article that has been accepted by a refereed journal on some phase of laboratory animal medicine.

One indicator of the need for laboratory animal medicine veterinarians in biomedical research is the increased amount of NIH funding directed toward animal-related research. From 1990 through 2002, live, vertebrate animal-based research accounted for approximately 43% of the research grants competitively funded annually by NIH (Figure 2-1). However, since the mid-1990s, the total number of research grants has increased, resulting in a 31.7% increase in the number of competitive grants utilizing animals between 1995 and 2002. In essence, there were approximately 1,300 more competitive grants utilizing animals funded in 2002 than in 1995.

Unfortunately, there is no way to estimate the additional burden of this increase in competitive research grants on veterinary care programs because there is no way to identify the number of animals that would be utilized in research funded by those grants. However, the USDA tracks the number of AWA-covered species used in research; between 1995 and 2001, the number of AWA-covered animals used in research decreased 11.3% from 1,395,463 to 1,236,903. From these data, it would appear fewer animals are used in biomedical research, except that AWA-covered species have been estimated to include less than 15% of vertebrate animals used in research (Goodrich et al., 2000). The AWA does not include rats, mice, or birds, and because rats and mice are the most commonly used species in biomedical research, it

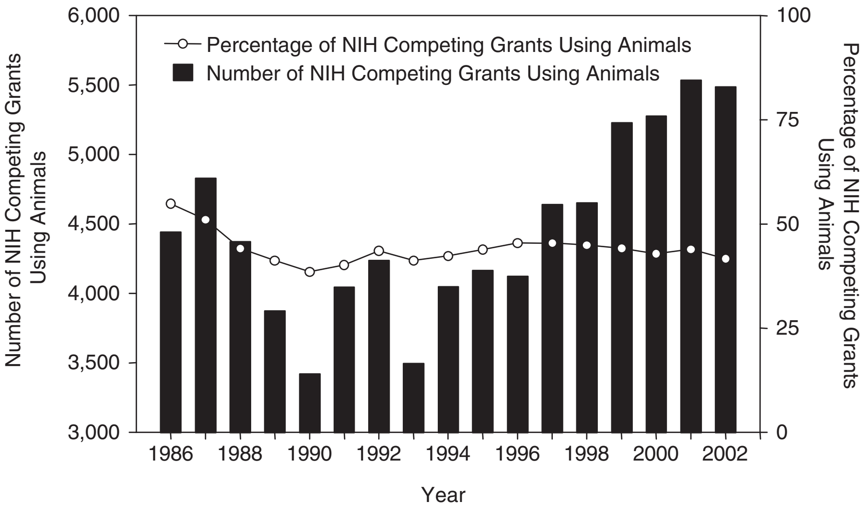

FIGURE 2-1 Historical trends of animal use in NIH grant portfolio.

NIH competing research grants from 1986-2002 were assessed for use of live, vertebrate animals (excludes research training, fellowship, construction, and medical library grants and R&D contract awards). *Source:* NIH Office of Laboratory Animal Welfare.

is not expected that the USDA inventories accurately reflect changes in the numbers of animals utilized in research.

Although 95% of rats and mice used in research are subject to PHS Policy and NIH oversight (Goodrich et al., 2000), accurate inventories of the number of rats and mice used in research are not kept, making it difficult to document changes in the utilization of rats and mice. Estimates are 12 to 15 million rats and mice were utilized for research in 1983 (US Congress, 1986) and 23 million in 1998 (Trull and Rich, 1999), with indications that mouse use alone will continue to increase by 10% to 20% annually over the decade 2000–2010 (Malakoff, 2000). If these predictions hold true over the next decade, by 2010 the US biomedical research enterprise could be utilizing more than 200 million rats and mice per year.

A previous study of the supply of and demand for laboratory animal medicine veterinarians (Weigler et al., 1997) concluded that there would be no increase in the demand for laboratory animal medicine veterinarians from 1994 to 2005, based partially on the assumption that NIH funding of research involving vertebrate animals had reached a steady state. However, starting in 1997, there was an increase in the annual rate of growth of the

NIH budget along with a steady increase in the number of NIH competing grants that utilize animals. These increases coincided with legislators in 1997 calling for a doubling of the NIH budget over 5 years. This 5 year doubling was officially set in motion during the 1999 fiscal year appropriations cycle (Mervis, 1997) (Figure 2-2). Neither the dramatic increase in the NIH budget nor the increase in the total number of NIH grants utilizing animals was predicted when it was concluded that the laboratory animal veterinary workforce had reached a steady state.

Nevertheless, although these data would suggest an increased demand for laboratory animal medicine veterinarians during the last 5 years, the current workforce may indeed be adequate if there was a concomitant increase in the number of laboratory animal medicine veterinarians. Examination of the ACLAM membership (Table 2-1) during this time period (1997-2002) reveals the annual rate of growth in the membership of active ACLAM diplomates was less than 3%. In total from 1997 to 2002, there was a 15% increase in the number of active ACLAM diplomates. Most positions of attending veterinarian or director of a laboratory animal facility

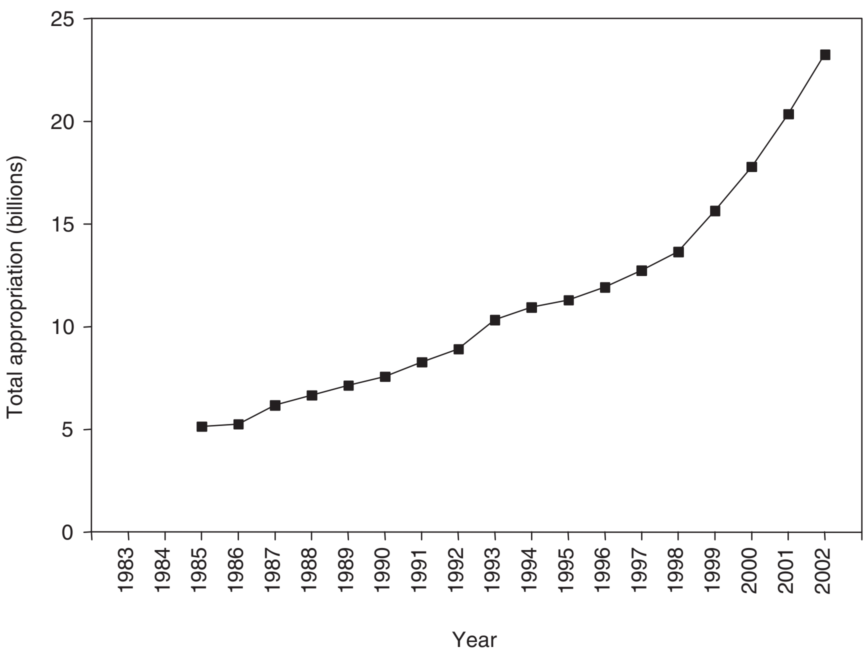

FIGURE 2-2 Total budget for the National Institutes of Health, by fiscal year. *Source:* National Institutes of Health, Office of the Director.

TABLE 2-1 Active ACLAM Diplomates

	1996	1997	1998	1999	2000	2001	2002
Active diplomates	564	579	597	620	633	643	666

Source: American College of Laboratory Animal Medicine.

require or strongly encourage ACLAM board certification, although in the committee's experience fewer positions for laboratory animal medicine veterinarians have required board certification in recent years because of the perceived lack of available ACLAM diplomate applicants. Taken together, the 30% increase in competitive grants utilizing animals and the 15% increase in ACLAM membership might suggest that there is not an adequate number of appropriately trained laboratory animal medicine veterinarians in the workforce. However, it is not possible to correlate these data directly because data on the total (competitive and noncompetitive) number of grants utilizing animals are not available.

Another indication of continuing demand for laboratory animal medicine veterinarians is the growth in professional income. The estimated mean salary of laboratory animal medicine veterinarians over the period 1996 to 1999 increased from $86,236 to $99,095 (15% over 3 years). Even if extremes in salaries are eliminated, laboratory animal medicine veterinarian salaries outpaced inflation by 6.4% (Weigler and Slattum, 2001), suggesting that an imbalance in supply and demand could be driving the increase in laboratory animal medicine veterinarian salaries.

Further evidence provides direct insight into the adequacy of the laboratory animal medicine veterinary workforce. Currently, an estimated 1,608 research institutions in the US* are USDA-registered and/or hold NIH assurances.† In contrast, only 666 individuals were active ACLAM diplomates in 2002. It should be noted that many research institutions register multiple research sites or campuses through the same registration or assurance, and this estimate of 1,608 research institutions would underestimate

*This estimate is an unpublished tabulation of all USDA-registered research facilities (as of December 11, 2002) and all NIH assured facilities (as of June 3, 2003), with duplicates removed. Domestic institutions include those within the 50 states and the US territories of Puerto Rico and Guam. For the purposes of this estimate, a facility was identified as a research organization based on its unique USDA certification number or NIH assurance number. This estimate does not include additional sites that may be registered or assured through a parent facility.

†Each research facility in the US that utilizes Animal Welfare Act-covered species (warm-blooded vertebrates other than rats of the species *Rattus*, mice of the species *Mus*, and birds) or utilizes live, vertebrate species at a facility that is supported by PHS funding must be registered with the USDA or hold an NIH assurance, respectively.

the number of facilities that would require a veterinarian to oversee the care of the laboratory animals. While it is recognized that attending veterinarians are not required to be ACLAM certified, these data suggest that there is a severe shortage of appropriately trained laboratory animal medicine veterinarians in the workforce.

The large, unexpected increase in the number of competitive grants utilizing animals and the large discrepancy between the number of institutions that are required to be overseen by a laboratory animal medicine veterinarian and the number of ACLAM diplomates are reflected in the number of position announcements for laboratory animal medicine veterinarians advertised in the major trade journals (Figure 2-3). Publication of position announcements for laboratory animal medicine veterinarians has been documented in the past (NRC, 1982; Weigler et al., 1997), which

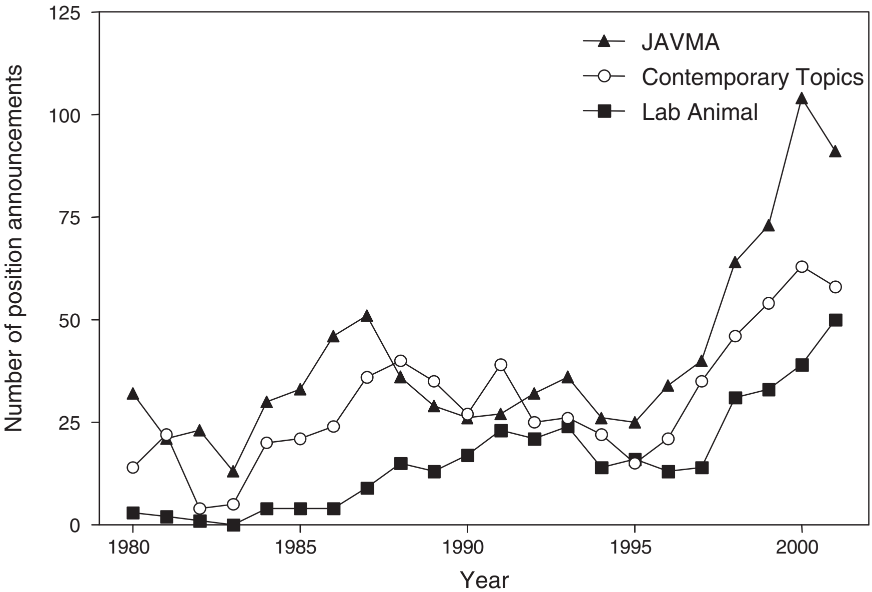

FIGURE 2-3 Number of position announcements for laboratory animal medicine veterinarians, 1980-2001.

Position announcements appearing in classified-advertisements sections of Journal of the American Veterinary Medical Association (JAVMA), Contemporary Topics in Laboratory Animal Science (Contemporary Topics), and Lab Animal were tallied. Data for 1980-1995 from Weigler et al., 1997. From 1980 to 1990, the classified advertisement section now found in Contemporary Topics was printed in the AALAS journal Laboratory Animal Science.

allowed the authoring committee to examine trends in position announcements for possible indications of demand for the position. Building on data gathered by Weigler et al. (1997), the number of position announcements for laboratory animal medicine veterinarians in three major journals from 1980 to 2001 was tallied (Figure 2-3). From 1995 to 2001 there was approximately a 250% increase in the number of position announcements from 56 announcements in 1995 to 199 announcements in 2001. It is not evident whether specific advertisements appearing in more than one journal or more than one issue of a journal represented turnovers in positions or multiple attempts to fill single positions. Thus, these data do not reflect the actual number of available laboratory animal medicine veterinarian positions, but rather may indicate an increased demand that may or may not have been adequately fulfilled. This large increase in position announcements could reflect a large increase in the total number of positions for laboratory animal medicine veterinarians, the retirement of large numbers of laboratory animal medicine veterinarians, an inability of employers to find qualified laboratory animal medicine veterinarians, a high turnover of laboratory animal medicine veterinarians, or a combination of these situations. Although it is impossible to determine the specific cause of the large increase in position announcements, these data support the suggestion that the increase in NIH-funded grants utilizing animals created an increased demand for laboratory animal medicine veterinarians. The small annual growth in the membership of ACLAM along with the large discrepancy between facilities that require a laboratory animal medicine veterinarian and the total membership of active ACLAM diplomates further support the conclusion that the current workforce of laboratory animal medicine veterinarians is inadequate.

VETERINARY PATHOLOGISTS

The subpopulation of the comparative medicine veterinary workforce composed of veterinary pathologists was recently surveyed by the American College of Veterinary Pathologists (ACVP, 2002). While this data set was the most comprehensive available to the authoring committee, the information was not derived exclusively from veterinary pathologists engaged in biomedical research, but included demographics on the entire veterinary pathologist workforce. The ACVP survey, undertaken during the summer of 2002, was commissioned to determine whether there currently was a shortage of veterinary pathologists.

This survey determined that in 2002, there was an estimated deficit of 67 anatomic and clinical pathologists in the veterinary pathologist workforce (ACVP, 2002). This estimate was based on a survey of 279 employers of veterinary pathologists in the United States and Canada (60.0% response

TABLE 2-2 Active ACVP Diplomates

	1997	1998	1999	2000	2001	2002	2003
Active diplomates	1119	1145	1194	1223	1236	1244	1268

Source: American College of Veterinary Pathologists.

rate) and 58 veterinary pathologist training programs (67.2% response rate). Based on this survey, the total workforce of veterinary pathologists in the United States and Canada was approximately 1,897 veterinary pathologists in 2002.* The active membership of ACVP in 2002 was 1,244 (Table 2-2), suggesting that approximately one third of the veterinary pathologist workforce does not have board certification in veterinary pathology. The membership of ACVP (Table 2-2) reflected increases in growth similar to that seen in the ACLAM membership (Table 2-1). The active membership of ACVP increased by 13.3% from 1997 to 2003, with an average annual growth of 2.1%.

The majority of survey respondents in the ACVP survey indicated that it took 7 or more months to fill an open position, and only one or two qualified individuals applied for each open position. More than 25% of respondents indicated that it took 13 to 18 months or more than 19 months to fill an open position. The majority of respondents also indicated that their primary barrier to recruiting qualified job applicants was a limited number of qualified pathologists, and approximately 80% of respondents indicated that a limited number of qualified pathologists was a factor in their struggle to recruit qualified job applicants (ACVP, 2002).

While the results of the ACVP survey establish a need for veterinary pathologists, NIH has identified a specific need for mouse pathologists (NIH, 1998). This need was identified during the NIH workshop "Priority Setting for Mouse Genomics and Genetics Resources," convened in March 1998 by then NIH Director Harold Varmus. During this workshop, a series of action items were outlined and included "a training program to support veterinary fellows in a two year fellowship in mouse pathology should be implemented" (NIH, 1998). In a subsequent follow-up meeting, NIH identified several types of training programs that were developed "to increase the number mouse pathobiologists" (NIH, 2000). These programs included

*An unpublished estimate based on the results of the ACVP survey. The estimated total workforce was calculated from the survey response rate, the percentage of organizations that employ an anatomic/clinical pathologist, and the average number of pathologists employed per organization. This estimate is based on the assumption that the percentage of organizations that employ an anatomic/clinical pathologist and the average number of pathologists employed per organization is similar in the respondent and nonrespondant organizations.

the Special Emphasis Research Career Award (SERCA) in Pathology and Comparative Medicine and the Mid-Career Investigator Award in Mouse Pathobiology (K26) award.

In 1998, the SERCA award was expanded to include research on genetically modified animals; however, this award encompasses any type of comparative medicine research, with no special emphasis on pathology or mouse models. In contrast, the K26 award announcement states that "the NIH is especially interested in increasing the number of scientists trained to conduct high-quality mouse pathobiology research." The objective of the award is to "encourage experienced, midcareer pathobiologists to . . . increase their mentoring of beginning investigators in mouse pathobiology to build up the pool of skilled mouse pathologists who can fill the growing need for trained professionals to contribute in the exciting discoveries being made using genetically altered mice for biomedical research."

NIH Support of Comparative Medicine

Although the discipline of comparative medicine and the need for well-trained, experienced veterinarians stretch across the institutes of NIH, only the National Center for Research Resources (NCRR) Division of Comparative Medicine directly funds the research-training and career-development awards of veterinarians (except for K08 awards that are funded by individual institutes). Therefore, it is disappointing that due to policy priorities, the various divisions of NCRR have not benefited equally from the doubling of the NIH budget. As seen in Figure 2-4 from 1995 to 2002, NCRR's budget increased by 204% while there was only a 42.9% increase in the Division of Comparative Medicine's funding.

VETERINARIANS AS PRINCIPAL INVESTIGATORS

To examine the comparative medicine veterinary workforce that participates in biomedical research as principal investigators, the authoring committee used research project grant (RO1) funding both to identify this population and to measure its growth and success (Figure 2-5). During the period of the doubling of the NIH budget (1997-2001), the overall increase in the number of RO1 awards was 33%. The number of RO1 grants awarded to individuals with a DVM (DVM, DVM-PhD, or DVM-MD) during this period increased 103% from 127 in 1997 to 258 in 2001.

DVM-PhDs in particular competed successfully during this time frame (1997-2001). The number of RO1s awarded to DVM-PhDs increased by 161%. However, the number of RO1s awarded to DVM-PhDs continues to be quite small: 154 RO1s awarded in 2001 compared with 3,071 awarded to MD-PhDs.

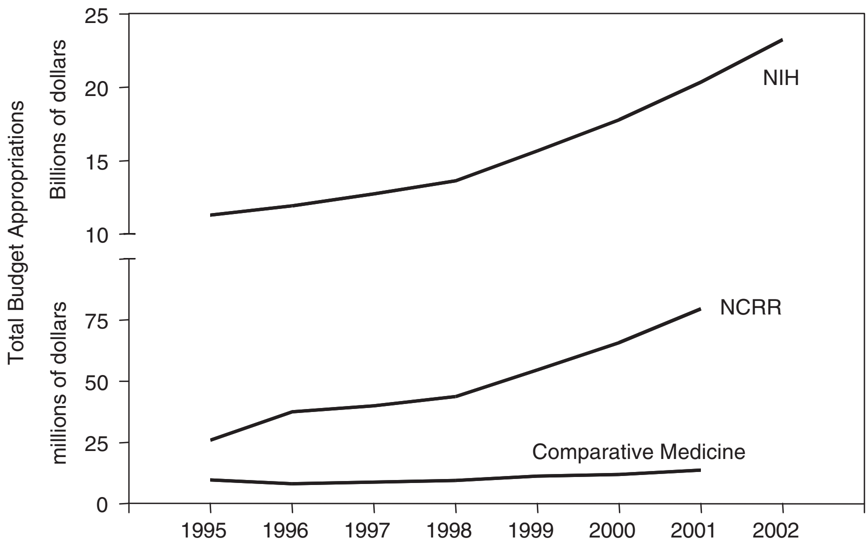

FIGURE 2-4 Annual budgets of NIH, NCRR, and NCRR Division of Comparative Medicine.

From 1995 to 2002, NIH experienced a doubling in annual budget. From 1995-2001, the budget of NCRR increased 204% and the budget of NCRR Division of Comparative Medicine increased 42.9%. *Source:* National Institutes of Health, Office of the Director and National Center for Research Resources.

The period 1997-2001 also reflected an increase of 11.8% in the number of RO1s awarded to DVM principal investigators, which was similar to the 11.5% increase in awards to MDs. However, the absolute number of RO1s awarded to DVMs was quite small: 76 in 2001 compared with 5,597 to MDs.

A new category of veterinary principal investigators also became apparent during this time—that of the DVM-MD. DVM-MD principal investigators have received RO1 awards only since 1999; however, in 2001 there were 28 grants awarded to DVM-MDs.

While it is evident that an increased number of veterinary principal investigators are successfully competing for RO1 funding, the total number of veterinarians with RO1 funding is still extremely small. In 2001, only 172 veterinary principal investigators were RO1 funded (some veterinary principal investigators are awarded multiple RO1 grants). In all, the 258 RO1 grants awarded to veterinary principal investigators in 2001 comprise only 4.7% of all the NIH-funded competitive research grants that utilize

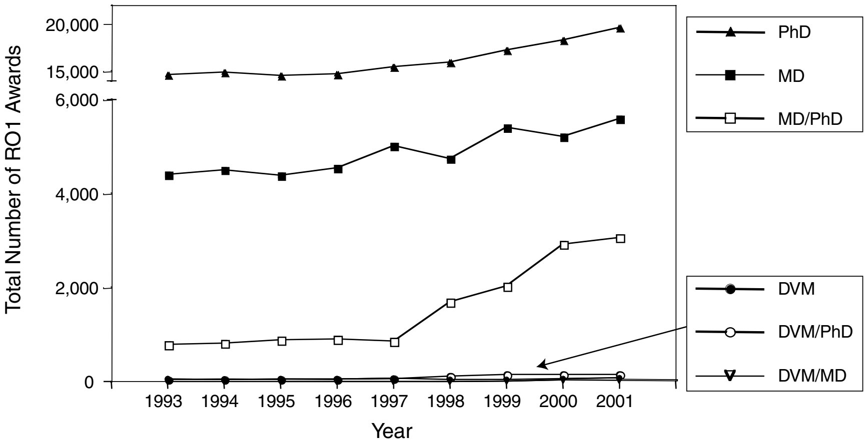

FIGURE 2-5 RO1 grant awards categorized by degree of principal investigator.

RO1 awards are coded by NIH by degree of principal investigator and include merit awards now designated as R37 awards. *Source:* National Institutes of Health, Office of the Director.

animals (see Chapter 3, "Increase in the Number of NIH-funded Grants Utilizing Animal Research," for further discussion). These data suggest that the current number of veterinary principal investigators who are conducting long-term research programs in the United States is not adequate, yet the training and experience that comparative medicine veterinarians possess makes them uniquely qualified to carry out animal research successfully. Because of the importance of using animal models in translational research, the veterinary principal investigator can also provide a critical bridge between the bench scientist and the clinical researcher. The necessity of veterinarians directly participating in and carrying out biomedical research was acknowledged during testimony at the NIH reauthorization hearings in 1996, when it was asserted that more efforts should be made to recruit veterinarians to interdisciplinary research teams (Cassell and McCauley, 1996).

3

The Future of the Comparative Medicine Veterinary Workforce

Having examined the adequacy of the comparative medicine veterinary workforce (Chapter 2), the authoring committee next turned its attention to projecting the future of this workforce. In order to develop an accurate workforce projection, the current workforce must be accurately defined and reasonable assumptions made about future demands on the workforce, as well as the entry of new workers into the field and their propensity to change fields, or retire, or die. This model was used to project the demographics of a comparable workforce—that of PhDs in biomedical and behavioral research (NRC, 2000). However, as documented in Chapter 2, data are not available to quantify the size of the current workforce accurately, though available evidence suggests that the current workforce is inadequate. For these reasons, the authoring committee was not able to create simulated projections of the future of the comparative medicine veterinary workforce. The committee was thus prompted to recommend that the AVMA utilize its current methodology for surveying their membership and recent graduates of veterinary medical schools and extend that methodology to (1) gather demographic information on the veterinary graduates of postgraduate training programs (both research and clinical), and (2) to include questions pertaining to curriculum and career choices in the survey instruments completed by graduates of veterinary medical and postgraduate training programs. This information would greatly assist veterinary medical colleges, postgraduate training programs, and NIH in understanding the effect of debt burden, starting salaries, dynamics of the job market, and curriculum on career choices.

In spite of the recognition that a formal projection of the workforce was not possible, the committee was still compelled to gather and analyze available data pertaining to the future demand for comparative medicine veterinarians and the supply of veterinarians entering the workforce and, recognizing the limitations of these data, to draw conclusions. In this case, the only available data on demand pertained to laboratory animal medicine veterinarians and veterinary pathologists. So, in addition, the committee identified several factors that could conceivably affect the demand for comparative medicine veterinarians in the near future. Fortunately, however, data pertaining to the supply of comparative medicine veterinarians (e.g., from NRSA training programs and specialty training programs) were more readily available and are discussed below.

SUPPLY OF COMPARATIVE MEDICINE VETERINARIANS ENTERING THE WORKFORCE

Comparative medicine veterinarians can receive their postgraduate training in a clinical or research setting, through residencies or research training programs, respectively. Some comparative medicine veterinarians receive both clinical and research training.

Residencies

Typically, an institution bears the costs associated with a residency program. From the mid-1960s to the mid-1990s, a small amount of clinical training was supported by the federal government. Clinical training for those individuals in a T32 research training program was supported by the T32 award (the National Cancer Institute and the National Institute on Aging also supported clinical fellowships in pathology). However, in the mid-1990s, NIH re-evaluated the use of the T32 funding mechanism and notified awardee institutions that the award was primarily for research training rather than clinical training. Since then, there has been no federal support of veterinary residency programs, and academic institutions have had to bear the costs of their residency programs, although several pharmaceutical companies have begun supporting training positions within academic institutions (Bennett, 1994).

Laboratory Animal Medicine Residencies

The number of ACLAM-accredited laboratory animal medicine residency programs has not changed since 1995: 32 active programs were known to exist in 1995 (Weigler et al., 1997), and there were 32 in 2002 (Table 3-1). Of the 32 currently active programs, nine programs did not

TABLE 3-1 Clinical Residency Programs in Laboratory Animal Medicine

ACLAM-Recognized Residency Programs

- Baylor University[a]
- California Regional Primate Research Center
- City of Hope National Medical Center/Beckman Research Institute[a,b]
- Colorado State University[a,b]
- Columbia University
- Duke University[a,c]
- Emory University
- GlaxoSmithKline
- Johns Hopkins University
- Louisiana State University
- Massachusetts Institute of Technology
- Pennsylvania State University-Hershey Medical Center
- Pfizer Global Research and Development[a]
- Scripps Research Institute
- Stanford University[a,b]
- State University of Buffalo[a,b]
- Texas A&M University[a]
- Tri-Institutional Program[a,b]
  (combined program including Rockefeller University, Weill Medical College at Cornell University, and Memorial Sloan-Kettering Cancer Center)
- United States Army Laboratory Animal Residency Program
- University of Alabama-Birmingham
- University of California-Berkeley
- University of California-Davis
- University of California-Los Angeles
- University of Illinois-Chicago
- University of Maryland
- University of Michigan
- University of Missouri
- University of North Carolina-Chapel Hill
- University of Pennsylvania[c]
- University of Tennessee-Memphis
- University of Washington
- Wake Forest University

Non-ACLAM-Recognized Residency Programs

- Rutgers (currently applying for ACLAM accreditation)
- Virginia-Maryland Regional College of Veterinary Medicine

[a]No individuals completed the ACLAM-recognized residency program from 1996 to 2002.
[b]Recently obtained ACLAM recognition.
[c]Not currently accepting applicants.

have an individual complete the program from 1996 to 2002. Four of those nine programs were newly established programs that had recently received ACLAM certification. Rockefeller University also had not trained any individuals from 1996 to 2002, but has recently reorganized its program into the Tri-institutional Program, with Weill Medical College at Cornell University and Memorial Sloan-Kettering Cancer Center, and has reapplied and received ACLAM certification.

In an effort to ascertain how many individuals had completed laboratory animal medicine residency programs, ACLAM surveyed recognized residency programs in early 2003 (ACLAM, 2003). This survey revealed that the number of individuals who completed residency training was 25% lower in 2002 than 1996 (Figure 3-1). This decrease in trainees paralleled a 2002 survey of residency programs (Colby, 2002), showing that 46% of the programs indicated a decrease in the number of qualified applicants apply-

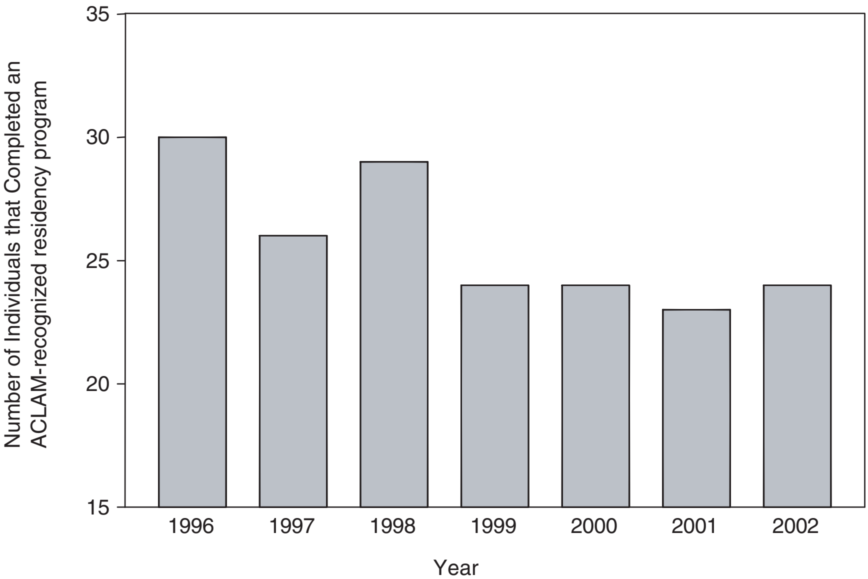

FIGURE 3-1 Number of individuals that completed a residency in laboratory animal medicine at an ACLAM-recognized program.

Reflects all trainees that completed a residency program in laboratory animal medicine from a currently active ACLAM-accredited program. Also includes individuals from recently inactivated or reorganized ACLAM-accredited programs, State University of New York at Stony Brook, North Carolina State University, Yale University, and Rockefeller University. *Source:* American College of Laboratory Animal Medicine.

ing for residencies (8% indicated an increase in the number of applicants, and 46% indicated no change). However, it was not apparent from the survey whether this decrease in qualified applicants resulted in a decrease in the number of applicants accepted into a residency program. Several of the programs did indicate that lack of funding limited the number of residency positions at their institutions.

While there has been an overall decrease in the number of individuals completing residency training annually, this trend is not reflected in the number of individuals obtaining board certification (ACLAM membership) over a similar time period (1997-2002; this timeframe assumes that a graduate of a residency program would sit for board certification in the year immediately following completion of residency). The total numbers of individuals who completed residency programs (156 from 1996-2001) and obtained board certification (152 from 1997-2002) are similar, but when the annual fluctuations in ACLAM active membership are examined (Table 2-1), it is evident that a smaller number of individuals received board certification in 1997 through 1999 than one would predict from the number of individuals who completed an ACLAM residency program in the preceding year (see Table 3-1), and in 2002 a much larger number of individuals received board certification than would be predicted. These data suggest that some portion of graduates of ACLAM residency programs are not obtaining board certification within one year of completion of their residency. In addition, the decline seen in the number of individuals completing ACLAM residency programs may not translate into a decline in the number of individuals obtaining board certification for another three to five years. Another alternative is that some portion of those individuals completing ACLAM residency programs are not obtaining board certification, but rather an approximately equal number of individuals are fulfilling their board requirements through work experience, rather than completing a residency program. This possibility also warrants concern because it suggests that resources are being used to train individuals who are not obtaining their board certification.

Residency Training through the Uniformed Services

To acquire veterinarians with experience in laboratory animal medicine for the uniformed services, it was necessary for the services to provide some of their members with the appropriate education, training, and experience. The US Air Force operated a residency program from 1961 to 1977, the US Army program has been in place informally since the 1950s, with a more structured program established in 1968, and the program at the Uniformed Services University of the Health Sciences (USUHS) was instituted during the 1990s (Kinnamon et al., 1999).

Most of the veterinarians that are trained in laboratory animal medicine through the uniformed services fulfill their 20-year obligation well before they reach retirement age. After their military service, these individuals are recruited into positions in the corporate and academic sectors. As of 1997, 32.7% of all ACLAM diplomates had received specialty training or experience that allowed them to sit for the ACLAM certification examination while on extended active duty in the uniformed services (Kinnamon et al., 1999). However, from 1998 through 2002, only 19.2% of new ACLAM diplomates had received their specialty training or experience through the uniformed services (ACLAM, 2003). This indicates that a larger percentage of the laboratory animal medicine veterinary workforce is being trained through ACLAM residency programs at academic and corporate institutions. As indicated in Figure 3-1, the overall number of graduates of ACLAM residency programs is also decreasing, which would indicate that the number of graduates of ACLAM residency programs with the uniformed services is declining at a faster rate than any decline in the number of graduates that may be occurring at ACLAM residency programs at academic and corporate institutions.

Veterinary Pathology Residencies

To estimate the current and future supply of veterinary pathologists, the American College of Veterinary Pathologists (ACVP), which administers the specialty-board certification for anatomic and clinical pathologists, surveyed both the employers and training programs of veterinary pathologists. While not every veterinary pathologist is engaged in biomedical research, this survey does provide some indication of the future of veterinary pathologists in biomedical research.

To perform this survey, the ACVP identified 278 employers of veterinary pathologists in Canada and the United States. A survey of this group (60.8% total response rate) indicated that the respondents employed 1,092 veterinary pathologists, which, extrapolated to include all identified employers, yields an estimated workforce in 2002 of 1,897 veterinary pathologists in Canada and the United States.* The survey also estimated 717 open positions for veterinary pathologists from 2002 to 2007.

*An unpublished estimate based on the results of the ACVP survey. The estimated total workforce was calculated from the survey response rate, the percentage of organizations that employ an anatomic/clinical pathologist, and the average number of pathologists employed per organization. This estimate is based on the assumption that the percentage of organizations that employ an anatomic/clinical pathologist and the average number of pathologists employed per organization is similar in the respondent and nonrespondant organizations.

This same survey also queried institutions that offered residencies in veterinary pathology. In 2002, there were 56 veterinary pathology residency programs with an estimated 381 veterinarians scheduled to complete a pathology residency between 2002 and 2007. Based on this survey, ACVP estimates that 336 positions will remain unfilled due to a lack of veterinary pathologists and that demand for veterinary pathologists will far outstrip the supply.

To identify underlying issues that might affect the supply of veterinarians being trained through residency programs, the ACVP survey also asked residency programs whether they had difficulty in recruiting qualified trainee candidates and whether there were limitations on the number of training positions available at their institutions. Of the residency programs, 77.7% indicated that it was somewhat or very difficult to recruit qualified trainees, and more than 90% indicated there were limitations on the number of training positions available at their institutions caused by lack of funding. When residency programs were asked to identify the barriers to recruiting qualified training candidates, a majority of the programs identified candidates' concern with debt and low stipends as two barriers to recruitment. Additionally, more than one-third of programs indicated that candidates believe their residency programs are too long (the majority of programs were identified as three-year residencies, see Figure 3-2).

Research Training Programs

The AAVMC identifies 30 US veterinary medical colleges or schools and departments of veterinary science or comparative medicine that offer PhD programs in comparative medicine, biomedical sciences, pathology/pathobiology, or laboratory animal medicine (Table 3-2). NIH supports some of those programs through NCRR-funded NRSA: Institutional Training Grants (T32s), which provide support for four to six trainees per institution (Table 3-2). At many of these institutions, the first year of clinical training is supported by the institution, which is a requirement for individuals to be supported by T32 funds. Many veterinarians will pursue PhDs during this training, although it is not required. In addition, some individuals will obtain board certification in laboratory animal medicine, having fulfilled the training prerequisites during their clinical training and T32-supported research training.

The T32 training grants are offered by NCRR's Division of Comparative Medicine to provide three years of support for training veterinarians for research careers in biomedical fields related to comparative medicine or comparative pathology. The program description for the T32 training grants states that:

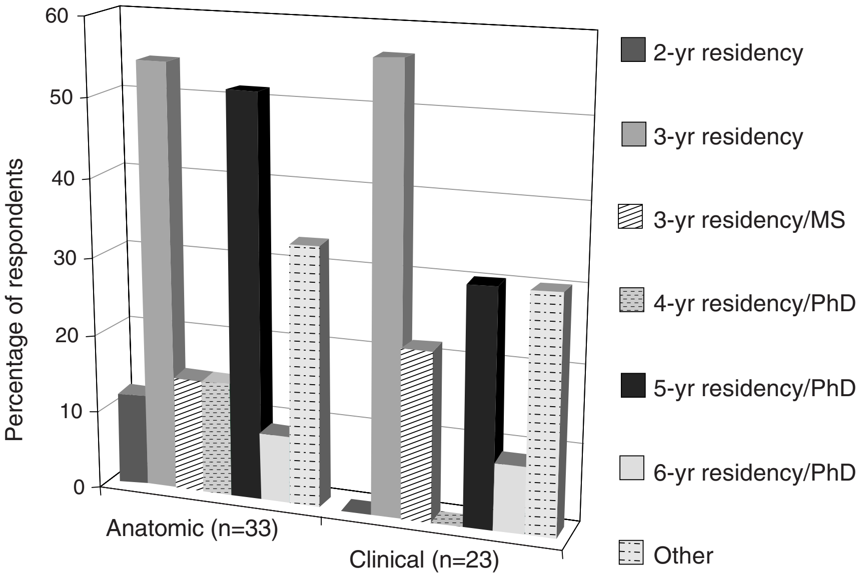

FIGURE 3-2 Type of veterinary pathology training program by specialty.

Reprinted from *Veterinary Pathologist Survey: Final Report* with permission of the American College of Veterinary Pathologists.

> the broad knowledge of veterinarians in whole animal-based biology, coupled with specialized research training provided by this program in comparative medicine, pathology, molecular biology and other biomedical areas, will equip trainees with strong foundations for research careers in biomedicine. Because of their unique training and expertise in veterinary medicine, graduates of the institutional training programs are often required, in addition to their activities as research scientists, to assume responsibilities that require a working knowledge of various animal resource-related issues. These include clinical and diagnostic medicine, selection of optimal anesthetics for specific types of research projects, resource management, training of research staff in the humane care and use of laboratory animals, and selecting the most appropriate animal models for particular studies. These types of activities are extremely important to ensure that high-quality, animal-based research is carried out and that the health and integrity of institutional laboratory animal colonies are protected.

During 1994 to 2002, the median number of T32 training grants funded per year by NCRR's Division of Comparative Medicine was 14 (range, 13-16). These T32-funded programs represent approximately half the research

TABLE 3-2 PhD Programs in Comparative Medicine, Biomedical Science, Pathology/Pathobiology, or Laboratory Animal Science at Veterinary Medical Colleges or Schools and Departments of Veterinary Science or Comparative Medicine

	NCRR-Funded T32 Programs (2003)
Auburn University	
Colorado State University	
Cornell University	Colorado State University
Harvard Medical School	Cornell University
Iowa State University	Harvard Medical School
Johns Hopkins University	Jackson Laboratory
Kansas State University	Johns Hopkins University
Louisiana State University	Massachusetts Institute of Technology
Massachusetts Institute of Technology	Ohio State University
Michigan State University	Pennsylvania State University-Hershey Medical Center
North Carolina State University	
Ohio State University	University of Alabama-Birmingham
Oklahoma State University	University of California-Davis
Oregon State University	University of Michigan
Purdue University	University of Missouri
Texas A&M University	University of Pennsylvania
Tufts University	University of Washington
University of Alabama-Birmingham	Wake Forest University
University of California-Davis	
University of Connecticut	
University of Florida	
University of Georgia	
University of Illinois-Urbana	
University of Michigan	
University of Minnesota	
University of Missouri	
University of Pennsylvania	
University of Tennessee	
University of Wisconsin-Madison	
Washington State University	

training programs in the United States (Table 3-3). The success rate of these T32 grant applications is fairly high, with an average of 60% (range, 40-75%) of these grant applications receiving funding. Each T32-funded institution receives funding for four to six trainees per year; therefore, up to two individuals per institution would complete a 3-year training program per year (approximately 28 individuals per year would complete T32-funded training). From 1998 through 2002 (when the number of NIH competitive grants utilizing animals increased), the T32 award mechanism had the potential to produce a total of 142 veterinary scientists. However, because this estimate of 142 veterinary scientists assumes that each institution is

TABLE 3-3 NRSA: Institutional Research Training Grant (T32) Awards Funded by NCRR, 1994-2002

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Number of Grants Awarded	14	15	16	14	14	16	13	13	15

Source: NIH, CRISP database.

funded for and utilizes six trainee slots each year, it is an overestimate. In addition, not all T32-funded programs utilize all the training slots they receive funding for; some institutions currently have as few as two trainees supported on the T32 grant (F. Greider, personal communication).

While 142 veterinary scientists is a welcome addition to the comparative medicine veterinary workforce, this small number of individuals will not significantly increase the number of research programs headed by DVMs. Assuming that even half of the 142 potential T32-trained researchers achieve success as independent researchers who obtain RO1 funding, the percentage of RO1 grants utilizing animals that are led by DVM principal investigators will still be less than 7%.*

ADDITIONAL FACTORS AFFECTING FUTURE DEMAND FOR COMPARATIVE MEDICINE VETERINARIANS

Agroterrorism and Bioterrorism

Since the attacks of September 11, 2001, and the dissemination of anthrax through the US Postal Service in the ensuing months, enormous resources—political, personnel, and fiscal—have been marshaled to prepare for bioterrorism attacks targeted directly at the American population or at its food supply. The National Institute of Allergy and Infectious Diseases alone will receive more than $1 billion in fiscal year 2003 for biodefense research (The Advisory Panel, 2002).

Considerable attention has been paid to bioterrorism agents, such as smallpox virus, that could be used to infect the American population directly, but there is increasing recognition that biologic and chemical agents can be spread through the agricultural system with potentially devastating

*This estimate assumes that each T32-trained, DVM principal investigator will obtain 1.5 RO1 grants (this is based on the average number of RO1 grants held per DVM PI in 2001), that the number of NIH funded grants utilizing animals will remain steady from 2001 levels, and that those DVM PIs that currently have RO1 grants will maintain the same level of funding.

effects. For example, during World War I, German agents infected horses with bacteria that caused glanders (NRC, 2002). This disease is contracted by humans through direct contact with an infected animal and can then be transmitted from human to human through sexual or other direct contact. A more recent example occurred in Wisconsin in 1996, when someone intentionally contaminated animal feed with chlordane, an organochlorine pesticide that accumulates in the fat of an animal and can be harmful to people who ingest meat from a contaminated animal (NRC, 2002).

The CDC identified 18 biological agents most likely to be involved in a terrorist attack (Table 3-4). These biological agents were prioritized into two groups, category A and B diseases/agents, which pose a risk to national security because they are easily disseminated or transmitted and have high mortality or morbidity rates. Of the 18 identified biologic terrorism agents, 11 are agents of zoonotic diseases; that is, animals are the natural reservoir of the agents, which can be transmitted to humans. That not enough veterinarians are trained in public health or in the diagnosis and control of

TABLE 3-4 Biologic Terrorism Agents List[a]

Zoonotic Agent	
	Category A diseases/agents
√	Anthrax (*Bacillus anthracis*)
	Botulism (*Clostridium botulinum* toxin)
√	Plague (*Yersinia pestis*)
	Smallpox (variola major)
√	Tularemia (*Francisella tularensis*)
√	Viral hemorrhagic fevers (e.g., Ebola, Marburg, Lassa, Machupo)
	Category B diseases/agents
√	Brucellosis (*Brucella* spp.)
	Epsilon toxin of *Clostridium perfringens*
√	Food safety threats (*Salmonella* spp., *Escherichia coli* O157:H7, and *Shigella*)
√	Glanders (*Burkholderia mallei*)
√	Melioidosis (*Burkholderia pseudomallei*)
√	Psittacosis (*Chlamydia psittaci*)
√	Q fever (*Coxiella burnetii*)
	Ricin toxin (from *Ricinus communis*)
	Staphylococcal enterotoxin B
	Typhus fever (*Rickettsia prowazekii*)
√	Viral encephalitis (e.g., Venezuelan equine encephalitis, eastern equine encephalitis, and western equine encephalitis)
	Water safety threats (e.g., *Vibrio cholerae* and *Cryptosporidium parvum*)

[a]Centers for Disease Control and Prevention Biologic Terrorism Agents List. Those marked with a checkmark are zoonotic agents.

zoonotic diseases reflects a lack of educational support and financial incentives for this aspect of veterinary science in the United States and the focus of most veterinarians on domesticated pets (The Advisory Panel, 2002). It has been noted that the emphasis of veterinary college curricula on clinical practice and research on diseases endemic in the United States causes a dearth of US-licensed veterinarians who have the expertise necessary to deal with agents of bioterrorism, which are often exotic animal diseases or diseases only infrequently encountered in the United States (The Advisory Panel, 2002).

Need for Integrative and Whole Animal Biologists

The need for integrative and systems biologists has increased in the last half-decade. Translating the rapid advances made at the molecular and cellular level into advances in the prevention and treatment of diseases requires a cadre of scientists trained in comparative medicine and whole animal biology.

This need is reflected in the Senate Committee on Appropriations report on the 2002 appropriations bill for the Department of Health and Human Services. The Senate committee recommended increased support for research and training in systems and integrative biologic disciplines, given that there has been diminished support for research and training in systems and integrated biology during the last 2 decades in favor of cellular and molecular research. The Senate committee also noted that the erosion of support for systems and integrated biology threatened to lower the rate at which the discoveries made at the cellular and subcellular levels are translated into useful therapies (Harkin, 2001).

The need for specialists in comparative medicine was also highlighted by a National Research Council report (NRC, 1998a) stating that "there is a need for experts in comparative medicine who are well trained in laboratory animal medicine and in research methodology." Comparative medicine veterinarians are particularly well suited for comparative medicine research in that their veterinary-school training is oriented to multiple species and they often receive both clinical and research postgraduate training. Postgraduate research-training programs that are funded by NRSA: Institutional Training Grants (T32) require applicants to have completed at least 1 year of postgraduate clinical training before being accepted as postdoctoral research fellows on T32 training grants.

Need for Clinically-Oriented Comparative Medicine Veterinarians

Societal demands have brought about a heightened awareness of the need to accommodate for animal well-being and have stimulated the biomedical community to focus on and learn about animal pain and distress (NRC, 1992). The demands of the public have resulted in an evolution in the standards for laboratory animal care and use, which now require more hands-on involvement of qualified laboratory animal medicine professionals in the management of individual animals. Individual animals must be provided with pain control and distress relief, their aberrant behavior addressed, and their well-being ensured. As the handling and management of individual animals in a research environment become more refined, more clinically oriented veterinarians must be available to provide direction and oversight of animal health and well-being.

Regulatory Requirements

Another reason for the increased need for comparative medicine veterinarians is the growing regulatory requirements related to the use of animals in biomedical research. In fact, the rapid growth in demand for laboratory animal medicine veterinarians during the mid- to late 1980s (Figure 2-3) coincided with new federal legislation regulating the use of animals in research (Federal Register, 1991; Health Research Extension Act of 1985, 1985), though there was a decrease in the number of NIH competing grants using animals (Figure 2-1) (Weigler et al., 1997).

Most research institutions are now subject to the Animal Welfare Act (AWA) and Public Health Service (PHS) Policy, and many are accredited by the Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC International). By the end of the 1990s, overlapping and redundant policies and increased regulations originating from the AWA and PHS, as well as the growing importance of achieving voluntary accreditation by AAALAC International, created new documentation and reporting requirements that resulted in attending and staff veterinarians devoting much more time toward maintaining regulatory compliance for animal-based biomedical research (NIH, 1999).

Responsibility for directing and managing an institution's animal care and use program generally falls to the attending veterinarian, who must have training or experience in laboratory animal science and medicine (NRC, 1996, p. 8), accompanied by responsibility for the institution's PHS Policy Assurance, fulfillment of USDA reporting requirements, and retention of AAALAC International accreditation.

Both the AWA and the *Guide for the Care and Use of Laboratory Animals* (NRC, 1996) require (1) that every institutional animal care and use committee (IACUC) have at least one doctor of veterinary medicine who has training or experience in laboratory animal science and medicine and has direct or delegated program responsibility for activities involving animals housed in the research facility (9 CFR 2.31(b)(3)(i); NRC, 1996);

(2) that medical care for animals be available and be provided as necessary by a qualified veterinarian (9 CFR 2.31 (d)(1)(vii); NRC, 1996); and (3) that procedures that may cause more than momentary pain or distress be planned in consultation with the attending veterinarian (9 CFR 2.31 (d)(1)(iv)(B); NRC, 1996).

Given the mandated requirements, it is common for an attending veterinarian to be an IACUC member, to direct an animal care and use program, to consult with researchers on the development of protocols, to oversee the daily observations of animals, and to provide veterinary medical care as needed. All that effort leaves little time to direct independent research projects or to collaborate with researchers on issues outside basic animal care and use. Those realities have contributed to the division of laboratory animal specialists into those who focus on clinical, regulatory, and administrative matters and those who focus predominantly on academic activities and research.

Infectious Disease in Laboratory Animals

The risks of infectious disease transmission and the ensuing adverse consequences in rodent colonies are increasing. The exchange of animals and animal products between facilities has increased, not only within the United States but also between facilities in the United States and abroad, where stringent disease prevention measures may not be in place. The risk of infection is greater in genetically modified rodents, whose response to infection is often unpredictable. The increasing size of institutional rodent colonies and the use of high-density housing systems are also increasing the risk of infection and complicating the ability of veterinarians to detect infectious agents. Respondents to a survey published in 1998 (Jacoby and Lindsey, 1998) were asked to identify factors affecting the ability of their institution to monitor and control infectious disease. The most commonly cited problem was inadequate financing, which resulted in an inability to attract and retain qualified veterinary personnel (Jacoby and Lindsey, 1998). Monitoring and controlling infectious disease require a team effort of veterinarians (and technicians) who specialize in medicine, pathology, and microbiology.

Infectious diseases of laboratory animals, particularly rodents, continue to affect biomedical research adversely. Laboratory rodents are susceptible to more than 50 infectious agents (Jacoby and Lindsey, 1998), and these can cause overt disease or subclinical infections, both of which affect the validity and reproducibility of research data (Rehg and Toth, 1998). An example is parvovirus, which is spread through contact with infected animals, equipment, and fomites. There are several strains of mouse and rat parvoviruses, and parvovirus-infected animals frequently manifest no pathologic changes, but infection with some strains can cause changes in the immune response and initiate autoimmunity (Smith, 2000). A national survey of rodent facilities at the country's leading biomedical research centers found that 27 to 40% of mouse colonies and 28 to 32% of rat colonies had parvovirus infections (Jacoby and Lindsey, 1998). Pinworms and mouse hepatitis virus are prevalent and may be found in up to 70% of rodent colonies (Jacoby and Lindsey, 1998). Emerging diseases caused by infectious agents, such as enterohepatic helicobacters, which cause chronic lower bowel inflammation in immunocompromised rodents and liver tumors in some inbred strains of mice, are being increasingly recognized (Fox and Lee, 1997).

Infectious disease outbreaks are caused not only by the introduction of an infected animal into a facility but also by the use of infected tissues and reagents. An outbreak of mousepox in a colony at Cornell University in 1999 was caused by the use of mouse serum contaminated with ectromelia virus, the causative agent of mousepox (Lipman et al., 1999).

The Importance of Animal Models and Their Increased Use

During the last 20 years, molecular and cellular scientists have made remarkable contributions to our understanding of human physiology and pathology. The biomedical research enterprise is on the cusp of a new era, that of translational research, which attempts to translate the gains of molecular and cellular biology into better prevention, diagnosis, and treatment of human and animal diseases. This type of research relies heavily on animal models, and all indications are that continued advances in genomics and proteomics will increase the use of animals, particularly rodents (Cassell and McCauley, 1996).

The development and use of transgenic animals—particularly rodents—has rapidly increased over the last 5 years. The publication of the human genome and the mouse genome has created a strong emphasis in biomedical research on functional genomics (NRC, 1998a). In light of the potential for 150,000 distinct mouse genotypes and thousands more phenotypes, it has been estimated that 60 million animals may be needed for mouse genomics research alone (Knight and Abbott, 2002). Many transgenic strains require intensive health monitoring, sophisticated husbandry, and incremental health care (Cork et al., 1997). High-quality care for the projected increase in the research rodent population would strain the current pool of laboratory animal medicine specialty-trained veterinarians.

An increase in the research rodent population not only would cause a strain on the pool of laboratory animal medicine veterinarians providing medical care for the rodent population, but also would require laboratory animal medicine veterinarians to train the many scientists who have little or no background in animal research and are developing genetically engineered mice, not widely developed until the last 5 years. The scientists often require training by veterinary staff to carry out experimental procedures and comply with regulations (Cork et al., 1997). It is also conceivable that as the genomes of other laboratory animal species are decoded, the demand for laboratory animal medicine veterinarians with specialized knowledge of dogs, cats, rhesus macaques, and other common laboratory animal species will increase.

Comparative medicine veterinarians are integral to the successful development and assessment of transgenic animals. They have the comprehensive knowledge of disease processes and human and rodent diseases that is necessary to develop animal models or to consult with scientists who are developing animal models (Gaertner et al., 1998). Comparative medicine veterinarians with advanced training in pathology, neurology, cardiopulmonary physiology, and animal behavior are essential to the successful development of transgenic animals.

4

General Conclusions and Recommendations

The data and findings detailed in Chapters 2 and 3 indicate that there is currently a shortage of veterinarians with expertise in laboratory animal medicine and comparative pathology. Evidence also indicates that veterinarian principal investigators comprise an unsatisfactorily small percentage of all RO1-funded principal investigators, and that to fully realize the potential of translational and transgenic research, more veterinarians need to be engaged in leading research programs involving integrative whole-animal research.

After reviewing all of the evidence available and deliberating on the cause of this shortage, the committee feels that while there are many factors that contribute to the lack of veterinarians in biomedical research, a key reason for this shortage is a lack of commitment from veterinary schools to educate veterinary students and graduates for careers other than private clinical practice. Veterinary schools and institutions that offer postgraduate training must reaffirm their role in educating students for all types of careers, including careers in biomedical research. Veterinary schools and postgraduate training institutions then must take steps to reshape pertinent policies and actions in the areas of admissions, recruitment, and curriculum.

The committee recognizes that many of the recommendations aimed at veterinary schools and institutions that offer postgraduate training will take several years to institute and reflect a long-term strategy for increasing the number of veterinarians entering postgraduate training programs. Therefore, the committee also developed short-term recommendations meant to increase the number of comparative medicine veterinarians over the next five years. These recommendations include retraining private clinical practice veterinarians for careers in biomedical research.

RAISING AWARENESS

The comparative medicine community must actively work to raise awareness of the role of veterinarians in biomedical research. Outreach programs should target the lay public, veterinary practitioners, and veterinary and pre-veterinary students. Educational campaigns can be very effective; however, it must be recognized that they are long-term solutions to an apparent shortage of comparative medicine veterinarians.

Veterinary Community

It is vital to raise awareness within the veterinary community of the importance of comparative medicine to both biomedical and veterinary medical research. Comparative medicine veterinarians need to influence decisions regarding curriculum within their veterinary schools. They should educate their fellow clinical faculty about the importance of research in general and encourage the use of examples of experimental research during didactic training. Professional societies could address this issue at a national level by encouraging the editorial staff of the *Journal of the American Veterinary Medical Association* to devote an issue to biomedical research.

Current and Future Veterinary Students

Comparative medicine veterinarians must be active in raising the awareness of middle- and high-school, college, and veterinary students about careers in comparative medicine. Veterinarians can be proactive by volunteering for outreach programs at middle and high schools, participating in undergraduate career forums, and supporting the establishment or expansion of veterinary student clubs. Faculty mentoring is perhaps the most effective tool for identifying students with an aptitude for and interest in comparative medicine. All comparative medicine faculty should make efforts to interact with first- and second-year veterinary students and to mentor those who show interest in comparative medicine. They should also ensure that their schools increase efforts to inform veterinary students of research training opportunities and should seek to establish research-training programs (summer externships and 1-year research fellowships for veterinary students) if they do not already exist at their institutions.

Professional societies, such as ACLAM and ASLAP, can also be proactive in their efforts to attract veterinary students to careers in biomedical science. This can be done by establishing and/or supporting a biomedical science career day at veterinary schools. Career days provide an opportunity to offer information and guidance to veterinary student on the various career pathways available to them in biomedical research.

It is important that veterinary students are made aware of the benefits of a career in comparative medicine. For example, the average salary of a laboratory animal medicine veterinarian in 2002 was $117,240 (Weigler and Huneke, 2003) compared with the average salary $83,979 of a veterinarian in private practice in 2001 (Anonymous, 2003). While higher salaries in comparative medicine careers will eventually draw more individuals into these careers, this type of market-based solution to the apparent shortage of veterinarians in the biomedical research workforce is a long-term solution, especially as it was not apparent to the committee that this information filters down to the student population. It is therefore important to also employ short-term strategies to address this shortage. These short-term strategies, such as retraining private practice veterinarians, are discussed later in this chapter.

Public Awareness

Veterinary societies must take a leadership role in educating the public through mass-media exposure to emphasize the importance of animals in biomedical research, the role of veterinarians in advancing biomedical research, and the role of veterinarians in refining and ensuring the humane care and use of laboratory animals. Veterinary societies should develop relationships with state biomedical research organizations—such as the Massachusetts Society for Medical Research, the North Carolina Association for Biomedical Research, and Connecticut United for Research Excellence—to establish outreach programs with local elementary and middle schools.

ACQUAINTING STUDENTS WITH CAREER OPPORTUNITIES IN COMPARATIVE MEDICINE

An effective method of maintaining student interest in comparative medicine throughout the veterinary-school experience is the use of summer research externships. Perhaps the best known of such programs is the Leadership Program for Veterinary Students, established in 1990 by Cornell University. Research training and experience are the foundation of the program, in which veterinary students pursue individual research projects under the guidance of Cornell faculty members. The aim of the program is to provide veterinary students with experiences that clarify and strengthen their commitment to careers in science. Students from 49 veterinary colleges worldwide have participated in the program. Participants are supported by NRSA: Professional Student Short-term Research Training (T35) awards, foundations, and industry. A recent survey of 280 of the 283 program graduates indicated that 44% have pursued research careers, 21% are engaged in postgraduate training or finishing veterinary school, and 34% went into private practice. Summer research externships provided through the program had favorable effects on the research interests of participants and their career trajectories.

The committee recommends that veterinary schools take advantage of the T35 awards. The number of T35 awards that provide 2 to 3 months of research training to veterinary students has increased steadily, by 400% over the last decade (Table 4-1), and the average success rate of competing applications is 66%. NIH should ensure the continued success of the T35 program with adequate funding.

In addition to summer fellowship programs, establishing 2- to 4-week externship blocks at academic institutions or in industry settings provides a good opportunity for veterinary students to be exposed to laboratory animal medicine. ACLAM has a funding mechanism that supports 10 externships per year. Industry has expanded the concept and contributes to the education of future comparative medicine veterinarians by offering opportunities for externships. Veterinary schools should aggressively educate students about the externships available.

Having recognized the importance of increasing the numbers of veterinarians in biomedical research, NCRR has instituted a new funding mechanism, an NRSA: Training for Veterinary Students in Animal-oriented, Hypothesis-based Research: Institutional Training Award—the "new" T32. This mechanism enables institutions to award grants to veterinary students to support one year of training in hypothesis-based laboratory animal medicine, comparative medicine, pathology, or a related field of biomedical research. The first of these awards will be funded in 2003.

VETERINARY-SCHOOL RECRUITMENT

To increase the number of veterinary school applicants who have an interest in comparative medicine, recruiters can target colleges and universities that offer bachelor's-degree programs in animal science or that

TABLE 4-1 NRSA: Professional Student Short-Term Research Training Grant (T35) Awards Funded by NCRR, 1995-2002

	1995	1996	1997	1998	1999	2000	2001	2002
Number of Grants Awarded	2	3	3	4	4	6	7	10

Source: NIH, CRISP database.

emphasize mentoring of undergraduates in biomedical research. By developing strong ties to those institutions, veterinary schools can ensure a steady flow of applicants interested in comparative medicine.

It is necessary for admission committees to recognize the need for and value of comparative medicine veterinarians. Veterinary schools should encourage their admission committees to select students with different backgrounds and career objectives to match the breadth of the veterinary profession's responsibility to society. Admission offices should make applicants aware that the selection committee values an interest in comparative medicine or previous research experience. Acceptance into veterinary schools is highly competitive, and applicants might not express an interest in a nontraditional career path, fearing that it will affect their chances of acceptance.

CHANGES IN VETERINARY-SCHOOL CURRICULUM

One way to increase the exposure of veterinary students to comparative medicine is through coursework in laboratory animal medicine. In a recent AAVMC survey of the top 27 NIH-funded veterinary schools, only six of 22 respondents required one or two courses in laboratory animal medicine (none required more), 13 offered electives (from one to six electives), and three offered no courses in laboratory animal medicine. Given those results and the clear need for veterinarians to enter comparative medicine, the committee recommends that all veterinary schools offer at least elective courses in laboratory animal medicine and that more veterinary schools require coursework in laboratory animal medicine. The coursework should emphasize facets of veterinary medicine involved in the research use of animals that is often absent in "pocket pet" coursework (pocket pet refers to rodents, rabbits, or other small animals kept as companion animals). Consideration should also be given to actively recruiting laboratory animal medicine specialists who are conducting peer-reviewed research for faculty positions at veterinary schools.

Veterinary students can be further exposed to careers in biomedical research by the liberal use of examples involving laboratory animals in other coursework to promote understanding of biologic and disease processes. Many students are unaware of how advances in prevention, diagnosis, and treatment of diseases were attained. By exploring the research that led to breakthroughs, the students not only are exposed to the indispensable role of laboratory animals in research but also gain an appreciation for the importance of the research endeavor to advances in veterinary and human medicine.

The committee acknowledges that although individual veterinary schools may recognize the importance of training laboratory animal medicine specialists, curricular content at many schools is influenced by state legislatures and national board content, which can lead to reduced emphasis on didactic training in comparative medicine. The committee recommends that AVMA's National Examination Board re-evaluate its emphasis on comparative and laboratory animal medicine in light of current societal needs. Veterinary schools must educate state government officials about the contributions of comparative medicine veterinarians to biomedical research and ultimately to the economy.

MENTORING

Although the Leadership Program for Veterinary Students has favorably influenced the career choices of its graduates toward research, a small group (2%) of its participants elected to pursue careers in private practice *after 6 years or more of postgraduate training*. Those few cited a lack of mentoring as contributing to their disillusionment with faculty appointments and to the challenges they faced in establishing independent research programs (D. McGregor, personal communication; McGregor and Fraser, 2002). That feedback highlights the importance of mentoring for veterinary students, residents, and postdoctoral fellows. Because the absolute number of veterinarians in comparative medicine is small compared with that in clinical practice, there is a constant need for individual veterinarians in comparative medicine to actively seek out and mentor students with an aptitude for and interest in comparative medicine. Veterinary schools focus on education for clinical domestic-animal practice, and most of their instructors are clinical practitioners. With such constant exposure to careers in clinical practice, the importance of every veterinarian involved in comparative medicine to be a mentor cannot be overstated.

FINANCIAL ISSUES

As highlighted by the ACVP survey, financial constraints are a source of serious concern to new veterinary graduates who are deciding whether to pursue postgraduate training. Debt burden and the comparatively low stipends available during postgraduate training are both factors. The AVMA annually surveys the graduates of veterinary medical colleges on employment, starting salaries, and education indebtedness. In 2001, the AVMA survey revealed that 85.4% of graduates of veterinary medical school incurred educational debt, and that 72% of indebted graduates had debt of $40,000 or more. The average debt was $67,819 (Wise and Gonzalez, 2002).

This level of debt is comparable with the educational debt incurred by graduates of medical school. In 2001, 82.8% of medical school graduates had incurred educational debt and 83% of indebted graduates had debt greater than $50,000. The average educational debt of medical school graduates in 2001 was $99,089 (AAMC, 2001).

In contrast, in 2001, only 49.5% of graduates of research doctorate programs (PhD, DSc, and EdD) in the life sciences had incurred educational debt. Of indebted graduates, only 29.7% had debt greater than $30,000 (data on average educational debt are unavailable) (Hoffer et al., 2002). These individuals are usually supported by training grants and/or RO1 awards to the faculty mentor.

It is evident that the educational debt incurred by veterinary medical graduates is significantly greater than that incurred by research doctoral graduates and is comparable with that incurred by graduates of medical schools. This difference is mostly due to the fact that the majority of research doctoral students receive support through teaching or research assistantships or fellowships. As evidenced by the 2001 Survey of Doctorate Recipients (Hoffer et al., 2002), only 15.1% of research doctorate graduates in life sciences used their own resources as the primary source of financial support. This is in contrast to veterinary medical graduates, who in 2001 indicated that on average, 91.2% of their educational debt was incurred while in veterinary medical school (Wise and Gonzalez, 2002).

The high debt burden incurred by the average veterinary graduate has been identified as a significant barrier to pursuing postgraduate training (ACVP, 2002). In 2001, the average starting salary of veterinary graduates entering private practice was $44,547, and the average starting salary of veterinary graduates pursuing postgraduate study was $21,966 (Wise and Gonzalez, 2002). The prospect of an additional 1 to 3 years for residency training or 4 to 6 years to obtain a PhD while earning stipend-level salaries is a major deterrent to pursuing postgraduate training.

To address concerns about the large debt burden that graduates of veterinary college face, a debt-repayment initiative similar to the NIH Clinical Research Loan Repayment Program should be initiated. In 2000, based on the assumption that large debt burden was a major impediment to medical school graduates pursuing postgraduate research training, the Federation of American Societies for Experimental Biology (FASEB) recommended that a national program for medical school debt forgiveness be established (Zemlo et al., 2000). In response, NIH established the Clinical Research Loan Repayment Program, authorized by the Clinical Research Enhancement Act (H.R. 2498). This program permits qualified health professionals who agree to conduct clinical research for 50% of their time for a 2-year period to receive education loan repayment equal to 50% of their debt up to $70,000. The Clinical Research Enhancement Act of 2000 indicated that one of the reasons for establishing the loan repayment program was the "average debt of $85,619" incurred by medical school graduates. The comparable debt incurred by the average veterinary school graduate is the basis for the committee's recommendation that NIH establish a Veterinary Research Loan Repayment Program that permits veterinarians who agree to conduct biomedical research to qualify for loan repayment.

Modest residency salaries present an additional hurdle to pursuing postgraduate residency training. In the ACVP study, 57.1% of pathology training programs identified low salaries as a barrier to recruiting qualified applicants (ACVP, 2002). Veterinarians participating in postgraduate research training programs are generally paid according to the NRSA postdoctoral salary scale. In 2002, the NRSA postdoctoral salary was $31,092 to $48,852 and was based on years of relevant research training. The minimum NRSA postdoctoral salary is targeted to increase to $45,000 within the next few years. In contrast, veterinary residency training salaries in laboratory animal medicine were as low as $25,000 and averaged only $31,883 (Colby, 2002). To address the financial barriers to postgraduate residency training, the committee recommends increasing veterinary residency training salaries to eliminate inequities between resident salaries and research training salaries.

The ability of academic institutions that sponsor residency programs to increase resident salaries is questionable because of the current economic difficulties faced by most universities and colleges. This academic constraint provides private industry with an opportunity to fund fellowships for training comparative medicine veterinarians. The growth of the pharmaceutical and biotechnology industries during the 1990s has contributed to the increase in demand for comparative medicine veterinarians. By contributing directly to residency training, private industry can actively participate in increasing the number of comparative medicine veterinarians.

POSTGRADUATE TRAINING

There are two avenues of postgraduate training for individuals interested in comparative medicine: clinical training (usually called residency training) and research training (often called postdoctoral fellowship training). While all comparative medicine veterinarians should receive research and clinical training to some extent, the main focus of a fellowship should be research training for the comparative medicine veterinarian interested in developing a career in research; the focus for a comparative medicine veterinarian developing a career in supporting biomedical research should be clinical training through a residency.

Training Comparative Medicine Principal Investigators

The committee has identified a need for more veterinarians to participate in biomedical research as principal investigators, and the first step toward this goal would be to increase the number of people in research training programs. The NIH granting mechanism for postgraduate research training is the NRSA Institutional Research Training Award (T32), funded by NCRR's Division of Comparative Medicine. The program provides up to three years of research funding for four or six postgraduate fellows per institution. Before an applicant is eligible for support through a T32 grant, the institution must support the first year of clinical training if the applicant has not previously had at least 1 year of clinical experience. This places a burden on the applicant who wishes to enter the training program immediately after graduation as well as on the institution, which must find alternative funding to support these individuals during the year of clinical training.

As seen in Table 3-3, since 1994, the number of T32 awards has been relatively stable; there has been no increase in the number of awards commensurate with the initiative started in 1998 to double the NIH budget. However, as noted in Chapter 3, the T32 program is currently underutilized, and many institutions do not utilize the award to train the full complement of trainees (four or six) funded through the award. The committee recommends that each awardee institution fully utilize its T32 award and train the maximum number of trainees for which funding has been awarded.

Congress established the NRSA in 1974 to consolidate the various research-training activities of NIH and the Alcohol, Drug Abuse, and Mental Health Administration. NRSA awards are to be made only in fields in which "there is a need for personnel" and should be responsive to research needs through periodic evaluations. In addition to developing young investigators with an interest in comparative medicine research, this program also provides a mechanism for quickly retraining private practice veterinarians in research methodologies to allow them to enter the comparative medicine workforce. However, in the committee's experience, T32 programs are seldom utilized for this purpose. The committee therefore recommends that if the current T32 program becomes fully utilized, NIH should consider increasing the funding to this program to accommodate additional awardee institutions.

Lack of federal funding for residency programs in laboratory animal medicine has been a topic of considerable debate since NIH re-evaluated the use of T32 awards to exclude the funding of clinical training (both MD and DVM residency training) in the 1990s (Jacoby and Fox, 1999). However, the T32 award still requires trainees to complete at least one year of clinical residency before they are eligible for support through the T32 award. The T32 training programs were forced to find alternative means to fund this clinical training, often coming up short (Jacoby and Fox, 1999).

Trainees who focus on integrative whole animal research would be exposed to the clinical aspects of research, in much the same way that physicians receive clinical training pertaining directly to patient-oriented research through a Mentored Patient-oriented Research Career Development Award (K23). This would also provide the trainees with clinical exposure to various animal models, eliminating the need for the one year residency requirement that has become a financial stumbling block for many T32 programs.

In addition to the T32 awards funded by NCRR, there are also the National Research Service Awards for Individual Postdoctoral Fellows (F32). The F32 award is to support "promising applicants with the potential to become productive, independent investigators." NCRR's Division of Comparative Medicine specifically funds F32 awards to veterinarians to receive research training in comparative medicine. However, these awards are underutilized (Table 4-2), as few individuals apply for the F32 fellowship (F. Greider, personal communication).

A groundswell of commentary on the need for physician-scientists during the middle 1990s (Shine, 1998) led to several changes, including reevaluation of the composition of integrated review groups and of the level of support of MD-PhD programs through the Medical Scientist Training Program (MSTP), which is administered by the National Institute of General Medical Sciences. Acknowledgment by the research community, and NIH in particular, of the need for physician-scientists led to the increase in participation of physician-scientists in biomedical research.

The committee recommends that veterinary schools with dual-degree programs seek support through the MSTP mechanism. Only one DVM-PhD program—at the University of Pennsylvania—is supported by the MSTP, and there have been no applications from veterinary schools in recent years. The University of Pennsylvania's MSTP program has been successfully training veterinarian-scientists since its inception in the late 1970s; 85% of its graduates hold research positions in academic, government, or industrial organizations or are pursuing postdoctoral training (A. Kelly, personal communication).

Several studies have recommended that there be no increase in the number of PhDs trained in the biomedical sciences (NRC, 1998b; NRC, 2000), but encouraging the pursuit of dual degrees for veterinarians would help to meet specific demands for integrative biologists and whole-animal scientists and would not contribute to the general overproduction of PhDs

TABLE 4-2 NRSA: Individual Research Training Grant (F32) Awards Funded by NCRR, 1995-2002

	1995	1996	1997	1998	1999	2000	2001	2002
Number of Grants Awarded	0	2	2	1	1	2	2	1

Source: NIH, CRISP database.

in the basic biomedical sciences. Veterinarians who receive dual degrees have unique clinical experience to contribute to the research enterprise, and they are in little danger of stagnating in postdoctoral or other temporary positions, as are many PhDs trained in the basic biomedical sciences (NRC, 2000).

Veterinary schools should also aggressively encourage their faculty to apply for NIH grants. Enriching the quality of comparative medicine research through competitive applications provides a greater opportunity for postgraduate training of veterinarians and the availability of faculty that can teach comparative medicine courses. However, from 1999 to 2002, NIH awards to veterinary schools have accounted for an average of 0.8% of all the funds awarded through NIH grants (Figure 4-1). These data imply

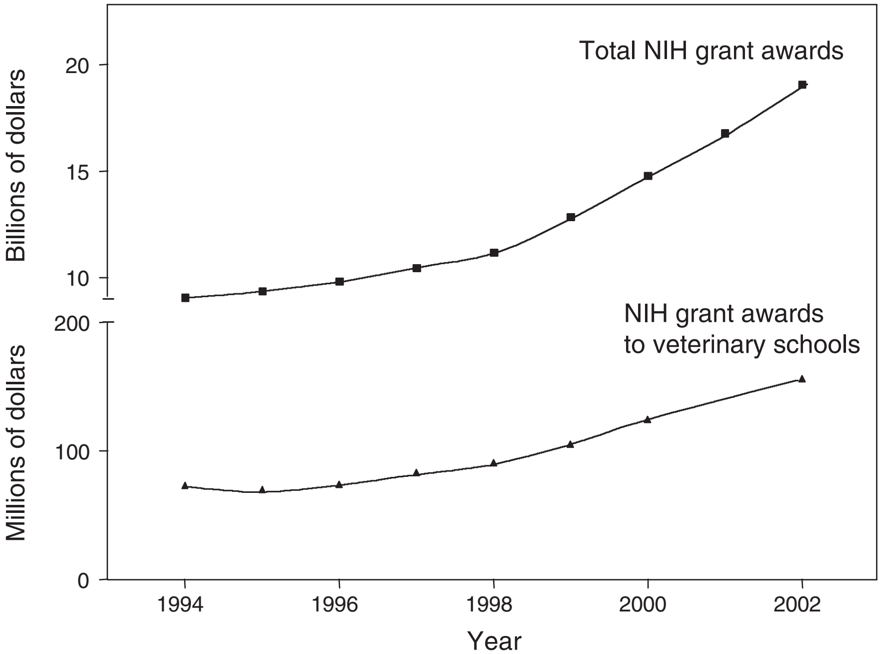

FIGURE 4-1 Total NIH grant awards versus NIH grant awards to veterinary schools.

During the same time frame of the doubling of the NIH budget (1999-2002), the increase in the total NIH grant awards and NIH grant awards to veterinary schools were similar (48.3% and 48.1%, respectively). However, NIH grant awards to veterinary schools comprised less than 1% of the total amount of NIH grant awards. Grant awards include research grants, training grants, fellowships, and R&D contracts. Data on NIH grants to veterinary schools were unavailable for the year 2001. *Source:* National Institutes of Health, Office of Extramural Research.

that there is an opportunity for veterinary schools to increase their research funding through NIH, especially in light of the increasing emphasis on translational research and the extensive use of animal models during the last 5 years.

To move veterinarians aggressively into roles as independent principal investigators, the K award system is administered by NCRR's Division of Comparative Medicine. The Special Emphasis Research Career Award (SERCA), also called a K01 award, is awarded by NCRR to help prepare veterinary researchers for faculty appointments (Table 4-3). It is the only K award targeted specifically for veterinarians.

In addition, there are a number of other K awards that are available to veterinarians, though it was not apparent to the authoring committee that young veterinarian researchers are being encouraged to apply for these awards. Nevertheless, some veterinarians have successfully competed for the Mentored Clinical-Scientist Development Award, K08, which is not funded by NCRR or specifically targeted to veterinarians. This award provides 3 to 5 years of support for mentored research experience and will support didactic training integrated into the research experience. In addition, there is a K23 award (Mentored Patient-oriented Research Career Development award) which is similar to the K08, except that it supports the career development of investigators with a commitment to focus their research endeavors on patient-oriented research.

Training Comparative Medicine Veterinarians to Support Biomedical Research Efforts

There is a great need for veterinarians to play an integral role in the biomedical research effort as clinical laboratory animal medicine veterinarians, pathologists, technical advisors, and animal resource program directors. The shift toward translational research has created a substantial need for veterinarians who have exposure to and experience with animal models in biomedical research to provide guidance to principal investigators. Not only has the reliance on animal models increased, but large numbers of investigators involved in molecular and cellular biology are also capitalizing

TABLE 4-3 Special Emphasis Research Career Award (K01). SERCA Awards Funded by NCRR, 1995-2002

	1995	1996	1997	1998	1999	2000	2001	2002
Number of Grants Awarded	19	22	19	18	20	18	20	24

Source: NIH, CRISP database.

on the recent advances in genomics with in vivo experimentation. Veterinarians who support biomedical research require exposure to research training but, most importantly, to clinical training in laboratory animal medicine or comparative pathology.

As discussed in Chapter 2, a two-fold problem appears to be resulting in a decline in the number of individuals entering and completing laboratory animal medicine residencies—a lack of qualified applicants and a lack of funding for residency programs. Unfortunately, it is not clear from the data whether one problem has a greater effect than the other on the supply of laboratory animal medicine veterinarians. It is apparent, however, that residency programs in veterinary pathology are also struggling to attract adequate numbers of qualified applicants. In the ACVP survey (ACVP, 2002), 78% of veterinary pathology programs described having a somewhat or very difficult time in recruiting qualified applicants.

While changes in veterinary-school curricula and the attitudes of veterinary-school faculty will eventually affect the applicant pool favorably, it may take many years to effect this change. Meanwhile, there are two courses of action that will positively affect the number of applicants: establishing a residency matching program and aggressively recruiting applicants.

The current veterinary residency-matching program is administered by the American Association of Veterinary Clinicians. This program, designated Veterinary Internship and Residency Matching Program (VIRMP), is patterned after the Physicians National Intern and Resident Matching Program. The applicant supplies the VIRMP with a ranked list of residency programs of his or her choosing. The residency program then supplies the VIRMP with a ranked list of applicants who applied to that program. The VIRMP then matches the applicant with the program based on mutual levels of interest. Currently, 26 veterinary specialties participate in this program, but neither laboratory animal medicine nor pathology programs participate. This committee recommends that ACLAM and ACVP facilitate the registration of their associated residency programs with the VIRMP; alternatively, ACLAM and ACVP could establish their own matching programs.

Concurrently, residency programs should recruit aggressively to increase the number of applicants immediately. There are indications that aggressive recruitment is effective. In 2002, one laboratory animal residency program recruited potential applicants aggressively and increased the number of applicants from approximately one to four per position (Colby, 2002).

Addressing the issue of scarcity of funding for residency programs is more problematic. It is apparent that this issue stems from the fact that there is no clear funding mechanism for residency training in areas of comparative medicine. While T32 programs were utilizing award money to fund trainees in clinical laboratory animal medicine or comparative pathology until the 1990s, residency programs have never had a formal funding mechanism through the federal government.

Medical schools and hospitals have a well-established funding mechanism for supporting residency training. Physician residency programs are funded by the federal government, mostly by Medicare through Direct Medical Education Funds that are paid per resident and Indirect Medical Funds that supplement payment for patient care (AMSA, 2003); however, there is no equivalent funding mechanism for residency programs in laboratory animal medicine (Jacoby and Fox, 1999) or comparative pathology.

Some have urged that individual institutions should support their residency programs by paying residents' salaries from funds generated by per diem charges for research animals being used at the institution or through other institutional funding mechanisms. Others have countered that these approaches would severely limit the training of comparative medicine specialists, and they defend the benefits of a more formal funding mechanism for laboratory animal medicine and comparative pathology residency training. Per diem charges are already severely impacting the budgets of investigators utilizing animals and it is the committee's opinion that principal investigator opposition to such an increase in per diem charges may be substantial and that few institutions would be able to successfully increase per diem charges to support their residency program. Additionally, academic institutions are facing other economic challenges that limit funding for professional salaries not covered by grant monies.

There is no easy answer to this problem. Unlike medical residency programs, laboratory animal medicine residency programs have no formal mechanism established for funding. Although PHS requires the involvement of trained veterinarians in the execution of animal-based biomedical research, NIH has a firmly established policy that precludes PHS support of any type of professional residency training. Another option for funding residency programs at institutions that use laboratory animals is through funds generated by per diem charges; however, this places the burden for training on the investigative community, which makes this approach untenable in most instances, given their operational fiscal constraints. In addition, although veterinary schools support residency training for many specialties, such as cardiology and surgery, the majority of laboratory animal medicine residency programs are found at medical schools versus veterinary schools. To date, most veterinary schools have not expanded their residency training opportunities into the field of laboratory animal medicine. Based on the committee's understanding of present funding options, the committee concludes that there is no mechanism currently available for procuring adequate and stable funding of laboratory animal residency programs. However, the committee strongly supports the concept that granting agencies, current residency programs, and veterinary medical schools be charged with developing new avenues to fund laboratory animal medicine residencies.

As discussed above, some residency programs have found alternative sources of funding from corporate entities (mostly pharmaceutical companies), who have acknowledged difficulties in recruiting qualified veterinary applicants for laboratory animal medicine and research positions. This problem has grown for corporate entities because they generate approximately 28% of the open positions for veterinarians (Table 4-4) and are the employers of an increasing number of ACLAM diplomates (Table 4-5). Several corporate employers have recognized that they can positively influence the pool of qualified applicants through support of postgraduate training (Bennett, 1994). These corporate employers support training through three mechanisms: (1) in-house residency programs, (2) cooperative programs with academic residency programs, and (3) by providing monetary support directly to residency programs. Organizations that have established in-house training and cooperative programs can benefit not only in the long-term, through an increased pool of qualified veterinarians, but also in the short term, through the skilled labor these veterinarians provide during their training. For other organizations that are too small or not interested in establishing residency programs, providing monetary support directly to academic programs is a way for them to contribute to efforts to increase the pool of qualified veterinarians. These innovative corporate employers have established several models through which other corporate entities can directly and indirectly help increase the pool of comparative medicine veterinarians.

TABLE 4-4 Mean Number of Employment Advertisements per Year (± SEM), by Sector, from COMPMED List-serv in 1999-2002[a]

	Average Annual Number of Job Advertisements ± SEM
Academic	68.5 ± 8.1
Industry	28.3 ± 5.0
Government	7.5 ± 2.4

[a]COMPMED is an e-mail forum for professionals working in biomedical research to discuss issues related to comparative medicine and laboratory animal medicine. Positions in organizations in the United States that required a DVM or VMD were tallied; duplicate postings were removed. Each position was categorized as academic (university or college), industrial (pharmaceutical, biotech, or laboratory animal breeding company), or government (NIH or USDA).

TABLE 4-5 Employers of Active ACLAM Diplomates by Sector[a]

Employer	1981	1991	2001
Academic Organization			
University or College	36	93	171
School of Medicine	54	64	67
School of Veterinary Medicine	20	24	13
Government Organization			
Military	40	30	33
Other (e.g., USDA, FDA, NIH)	35	39	48
Corporate Organization (e.g., pharmaceutical, biotech, lab animal breeder or supplier)	45	78	162
Hospital	7	12	25
Primate Center	2	4	9
Other (e.g., nonprofit research center)	27	23	46
None listed	7	25	69
Total	273	392	643

[a]Unpublished tally of employers of active ACLAM diplomates listed in the ACLAM membership directories from 1981, 1991, and 2001. Some individuals at academic institutions did not identify their school and departmental affiliation; therefore, the tally of veterinarians at schools of medicine and veterinary medicine may be artificially low while the tally of veterinarians at a university or college may be artificially high. Alternatively, DVMs in these categories my be providing professional support university-wide, as well as for specific schools and departments.

ATTRACTING VETERINARIANS INTO ROLES THAT SUPPORT BIOMEDICAL RESEARCH

To attract more veterinarians into roles that support biomedical research, academic institutions should provide faculty appointments to comparative medicine veterinarians. It is the committee's experience that many academic institutions do not provide faculty appointments to attending veterinarians, laboratory animal medicine clinicians, and other veterinary staff. Without an academic identity, comparative medicine veterinarians are often marginalized as "service staff," and their time is used to address the clinical and compliance issues inherent in management of an animal resource program. This allows little or no time to interact with principal investigators and research staff. That conundrum severely underutilizes their training and creates an environment in which comparative medicine veterinarians, who have many years of postgraduate training, are not active and productive participants in the research enterprise (NRC, 1998a).

The pharmaceutical and biotechnology industries provide an excellent example of the integration of veterinarians into biomedical research programs. Many veterinarians in industrial positions do provide clinical services, but a portion of their time is protected to interact with research staff and contribute to the research mission. Academic institutions can emulate that approach by appointing veterinarians to nontenure track faculty positions as clinician-scientists. Reinvigorating comparative medicine departments or integrating comparative medicine veterinarians into existing departments with appropriate faculty appointments will ensure that veterinarians have the opportunity to participate fully in research in a manner that matches their research training and experience.

Institutions must also evaluate the burden of regulatory and compliance issues on laboratory animal medicine veterinarians. The administrative role of the veterinarian changed dramatically during the 1990s. In 1996, the National Research Council's *Guide for the Care and Use of Laboratory Animal*, the reference mandated by PHS Policy, was revised. The revision detailed more clearly the responsibilities of the IACUC, such as endorsing biannual inspections, and the associated administrative duties that most often fall to the attending veterinarian. Accreditation of animal facilities by AAALAC International has grown in importance, also increasing the documentation and reporting responsibilities of the attending veterinarian. It is a common requirement for research institutions to comply with the AWA, the PHS Policy, and AAALAC International policies, each with its own oversight, documentation, and reporting mandates.

It can be advantageous for institutions to hire additional support staff to alleviate the regulatory tasks (such as annual reports and laboratory inspections) now given to veterinarians. One approach to increasing the support staff is to increase the size of residency programs; additional resident veterinarians could be assigned a limited role in the regulatory program, thereby relieving attending veterinarians of some of these responsibilities. Reassignment of these tasks would allow veterinarians to use their training more appropriately to provide advice to principal investigators and to participate actively in research design and implementation.

Recapturing Private-Practice Veterinarians

In 1999, the results of a study of the veterinary market predicted an excess supply of private practice veterinarians through 2008 (Brown and Silverman, 1999). Coupled with the stagnant income of private practice veterinarians (Brown and Silverman, 1999), these data suggest the existence of a pool of clinical practitioners who, because of economic pressures and disillusionment with private practice, may be interested in retraining for another kind of career. Professional societies related to comparative medicine should expose clinical-practice veterinarians to the opportunities and benefits of a career in comparative medicine. For example, in 2002 the average salary of a laboratory animal medicine veterinarian was $117,240

(Weigler and Huneke, 2003), a highly competitive salary when compared with the average salary of $83,979 for a private practice veterinarian in 2001 (Anonymous, 2003). This exposure could occur through advertising and articles in journals and trade publications, on professional web sites (such as AVMA's), and in exhibits at annual conferences. Residency and research training programs should be aware of this potential pool of applicants and actively recruit veterinarians with clinical-practice experience who desire a career change. Both types of programs (residency and research training) could provide retraining of a private practice DVM in one to three years.

RECOMMENDATIONS

- **The AVMA should utilize its current methodology for surveying its membership and recent graduates of veterinary medical schools and extend that methodology to (1) gather demographic information on the veterinary graduates of postgraduate training programs (both research and clinical), and (2) to include questions pertaining to curriculum and career choices in the survey instruments completed by graduates of veterinary medical and postgraduate training programs.**

- **To increase the number of applicants to veterinary schools and postgraduate training programs who have a sincere interest in comparative medicine, the comparative medicine veterinary community (as individuals and professional societies) must actively work to educate college and veterinary school students about the role of veterinarians in biomedical research, the training necessary to achieve these careers, and the benefits associated with careers in comparative medicine.**

- **Veterinary schools should aggressively seek out applicants with an interest in comparative medicine, and admissions committees should be encouraged to select applicants with interests outside private clinical practice.**

- **To encourage more student interest in careers in biomedical research, veterinary schools are encouraged to establish summer externship programs and also year-long research programs that can be supported through T35 and the "new" T32 (NRSA: Training for Veterinary Students in Animal-oriented, Hypothesis-based Research: Institutional Training Award) award mechanisms, as well as through institutional funding and partnerships with corporate sponsors.**

- **Veterinary schools should aggressively seek out applicants with an interest in comparative medicine, and admissions committees should be encouraged to select applicants with interests outside private clinical practice.**

- **All veterinary schools should offer at least elective courses in laboratory animal medicine, and more veterinary schools should require coursework in laboratory animal medicine.**

- **AVMA's National Examination Board should re-evaluate its emphasis on comparative and laboratory animal medicine in light of current societal needs.**

- **All comparative medicine veterinarians should actively seek out and mentor students with an aptitude for and interest in comparative medicine.**

- **To address concerns about the large debt burden faced by graduates of veterinary colleges, a debt-repayment initiative similar to the NIH Clinical Research Loan Repayment Program authorized by the Clinical Research Enhancement Act (H.R. 2498) should be initiated.**

- **Each awardee institution should take full advantage of its T32 award by utilizing all of the trainee positions for which they receive funding (between 4 and 6 trainees per year). In addition, if the current T32 program becomes maximally utilized, NIH should consider increasing funding to this program to accommodate additional awardee institutions. The requirement for one year post-DVM experience is unnecessarily placing barriers for DVM graduates wanting to enter training programs immediately after graduation. This requirement should be removed from T32 granting stipulations.**

- **NIH should consider emphasizing that the T32 award for veterinarians funded by NCRR can be utilized to train DVM researchers in integrative and whole animal-oriented research approaches and that the one year residency requirement should be removed as a contingency to receiving support through a T32 award.**

- **Research institutions and schools of veterinary medicine should encourage and support postgraduate veterinarians to apply for F32 awards.**

- **More veterinary schools should seek support through the NIH MSTP mechanism to strengthen their dual-degree (DVM-PhD) programs.**

- **Schools of veterinary medicine, faculty advisors, and research mentors should actively encourage young DVM researchers to apply for K awards and further actively provide the support necessary for young DVM researchers to successfully compete for these awards.**

• ACLAM and ACVP should facilitate the registration of their respective residency programs with the VIRMP.

• Granting agencies, current residency programs, and veterinary medical schools should be charged with developing new avenues to fund laboratory anmal residencies.

• Residency programs should aggressively recruit applicants through veterinary student clubs, national meetings, career days, etc.

• Academic institutions should be encouraged to provide faculty appointments to comparative medicine veterinarians that support biomedical research. This will integrate veterinarians into ongoing research programs and more fully utilize their expertise and training.

• Institutions should consider hiring additional support staff to assist with regulatory tasks, to allow veterinarians more time to interact with investigators and ongoing research programs.

• Professional societies and training programs should actively recruit interested private practice veterinarians into residency and research training programs to retrain for careers in comparative medicine.

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Appendix A

Specialized Veterinary Manpower Needs Through 1990

National Research Council
National Academy Press
Washington, D.C., 1982

EXECUTIVE SUMMARY

In April 1980, the U.S. Department of Agriculture (USDA), Food and Drug Administration (FDA), National Institutes of Health (NIH), Environmental Protection Agency (EPA), and U.S. Army Medical Research and Development Command (USAMRDC) asked the National Academy of Sciences to examine the impact of federal legislation and regulations on the national requirements for veterinary medical scientists. Accordingly, the Committee on Veterinary Medical Sciences of the National Research Council (NRC) Commission on Life Sciences was charged with assessing the effect of current legislation and regulations on the need for veterinary medical scientists with competence in various research and practice specialties. This led the Committee to consider the factors associated with services provided by veterinarians today, so that it could determine the total manpower needs. The Committee performed the following tasks:

- Defined functional responsibilities currently met by veterinarians.
- Identified organizational settings and biomedical disciplines in which veterinarians currently perform activities related to the defined functional responsibilities.
- Identified the number of veterinarians working in the organizational settings.

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- Analyzed appropriate federa11egis1ation and identified activities mandated or caused by that legislation related to the functional responsibilities and specialty disciplines of veterinarians.
- Estimated the future needs for veterinary specialists in major organizational settings.
- Projected the number of new veterinarians that will be produced during the next decade and the total population of veterinarians available for service during the same period.

Analysis of functional responsibilities of veterinarians revealed that their activities are usually multifaceted and have impacts of benefit to both animal and human health. The Committee defined 10 functional responsibilities: administration, animal health care, animal welfare, biomedical research, economic productivity of animal-related industries, environmental health protection, food production and protection, health education, mental and emotional health (as related to companion-animal care), and prevention of zoonoses.

The skills and expertise of veterinary medicine were found to be delivered to users through a variety of organizational settings, including private practice, institutional practice, preventive medicine, teaching and research, and industrial and international veterinary medicine.

Major findings of this report are threefold: the current numbers of veterinarians contributing to non-private-practice endeavors have been documented; the deficiencies in the existing data base concerning the activities of such veterinarians have been identified; and the total number of veterinary specialists has been determined to be small, with just over 2,000 board-certified specialists among the 8,760 non-private-practice veterinarians in 1981.

Despite the fact that the percentage of veterinarians not in private practice has decreased over the last decade, the Committee recognizes that veterinarians, by virtue of their expertise and skills, will continue to fulfill important societal needs in teaching, research, and administration. The Committee believes that the use of veterinarians by the non-private-practice sector has been limited by two factors: the economic incentives of private practice have outweighed those of alternative endeavors, thus holding down the supply of veterinarians for nonprivate practice; and some health professionals including veterinarians in decision-making positions, fail to adequately recognize that veterinarians can bring valuable skills and expertise to biomedical problem-solving and administration not associated with primary patient care.

The Committee believes that the use of veterinarians' biomedical expertise by government agencies should be expanded. We also believe that the use of veterinarians for tasks that can be performed by other trained persons should be decreased. Agency heads should be made aware of the skills, knowledge, and unique qualifications of veterinarians that could be applied to meet program goals and responsibilities and that federal salaries for veterinarians should be more competitive with those of Ph.D. and M.D. biomedical scientists, particularly if specialty training in addition to the veterinary degree has been obtained.

The analysis of federal legislation revealed many activities with an impact on the functional responsibilities of veterinarians. Some of these, such as laboratory-animal medicine and comparative pathology, are usually identified with the veterinary profession; others, such as toxicology, are not the exclusive domain of veterinarians, but veterinarians with specialty training could make contributions. The federal legislation influencing veterinary medical manpower is described in Appendix B.

The Committee has to estimate the future needs for services in the various organizational settings by analyzing each of the major veterinary-manpower studies completed since the 1961 Humphrey Report, by seeking the opinions of consultants and administrators in federal agencies and industry and by drawing on the knowledge of its own members. It is the opinion of the Committee that the need for veterinarians to deliver private-practice patient care in this decade will be met by the projected supply.

The lack of a suitable existing database makes it difficult, on the basis of historical employment trends, to predict future needs in the non-private-practice sector. Employment of veterinarians by the major U.S. regulatory agencies remained roughly constant during the last decade. Whether this was based on technical needs or on the availability of funds and appropriately trained persons was not determined. The employment of veterinarians by industry increased during the last decade, primarily in pathology and laboratory-animal medicine. Data gathered by the Committee indicate that there will be a demand for additional veterinarians in those disciplines in industrial and contract research laboratories. The Committee believes that such organizations as the Association of American Veterinary Medical Colleges (AAVMC) and the American Veterinary Medical Association (AVMA) should expand their data-gathering efforts to collect more information on the veterinary manpower used by the non-private-practice sector. A comprehensive survey of this sector should be conducted in the near future to assist in the development of predictions of employment in areas other than private practice. The Committee predicts that there will be an increased overall need for veterinarians in the non-private-practice sector.

The number of veterinary graduates produced each year for the rest of this decade is expected to increase modestly. The increase will be due primarily to the establishment of three veterinary schools in the latter 1970s; and the 1980s will see another school or two. The Committee does not foresee a need for additional capacity for the production of veterinary graduates. In fact, one may expect some decrease in training capacity in schools that expanded substantially during the last decade under the stimulus of capitation funding; this decrease will occur as individual states assume more of the total responsibility for instructional costs and as they assess their own state and regional manpower needs. The total population of veterinarians in the United States in 1990 is expected to be as high as 53,000.

In addition to students seeking a veterinary degree, many students (about 20%) enrolled in U.S. schools of veterinary medicine are graduate or postdoctoral students. Of these, the largest group is composed of students with veterinary degrees who are seeking either an M.S. or a Ph.D., and the others are students who are seeking advanced training leading to board certification. Although the number of board- certified veterinary specialists has been increasing steadily over the last decade, the total number of such specialists in the entire profession is still just over 2,000 in 1981. Thus the profession has relatively few specialists overall, and the Committee recommends that veterinary schools place more emphasis on the production of specialty-trained veterinarians of all kinds, especially in those disciplines in which the schools have particular faculty expertise. Such training should be obtained where there are appropriate facilities and personnel with experience.

To predict the specialty disciplines most likely to be in demand through 1990, the Committee looked at several demand indicators, including the increasing numbers of veterinary specialty-board memberships, number and types of employment possibilities as indicated by advertisements in veterinary professional journals, and the types of disciplines needed as a result of legislation and regulations. The fields cited in all three of these categories are clinical medicine, epidemiology, laboratory-animal science, microbiology, pathology, and toxicology. Persons in these fields are predicted to be most in demand and should be strongly recommended for postdoctoral, Ph.D., and other training.

The Committee offers the following specific recommendations:

Recommendation 1: National Reporting System

The Committee recommends that a comprehensive national reporting system be developed to determine accurately the number of veterinarians being used in all fields of employment. This should either be an expansion of the existing AVMA system or be developed in conjunction with the existing system.

Recommendation 2: Stabilization of Number of Veterinary Graduates

The Committee recommends that educational opportunities at the D.V.M. level be stabilized at the current number. The number of veterinary graduates appears to be in balance with manpower and service needs. Schools adversely affected by the cessation of capitation funding should consider decreasing their enrollments, to maintain the quality of professional training and to be able to provide postdoctoral training for veterinarians needed by the non-private-practice sector. Increases to meet regional needs should be accompanied by decreases in regions that are training veterinarians in excess of their own needs. Other ways to stabilize veterinary manpower include early retirement, retraining in midcareer, and programs specifically designed to deal with regional imbalances in numbers of practitioners.

Recommendation 3: Veterinary Medical School Programs

a. The Committee recommends that the colleges of veterinary medicine adjust their curricula, admissions criteria, and clerkship programs to meet societal needs in environmental health protection, food production and protection, economic productivity in animal-related industries, biomedical research, and animal welfare, as well as needs for clinical patient care of animals.

b. The Committee recommends that national guidelines for postdoctoral educational programs at veterinary colleges be established. The AVMA Council on Education should create or sponsor a special group to develop guidelines and evaluate graduate programs according to those guidelines.

Recommendation 4: Support for Postdoctoral Training

The Committee recommends that postdoctoral training for veterinarians be given high priority for support by federal and state government agencies responsible for financing higher education.

Recommendation 5: Increased Recognition of Veterinarians as Biomedical Scientists

The Committee recommends that use of veterinarians' biomedical expertise by government agencies be increased. Agency heads should be made aware of the skills, knowledge, and unique qualifications of veterinarians, which could contribute the agencies' program goals and responsibilities. Thorough evaluation of the contributions and productivity of veterinary biomedical scientists in the fields of concern to federal and state agencies is encouraged to inform decisions about future selection of personnel from among the various health professional and paraprofessional manpower resources.

Recommendation 6: Participation of Veterinarians in Economic Modeling and Agribusiness.

The Committee recommends that economic models be developed for the application of animal-health expertise to the livestock industries, possibly through the provision of expanded community or other agribusiness services. Multidisciplinary research involving veterinarians and agricultural economists should be encouraged. Economic modeling is one technique that should be explored in an effort to deliver veterinary services to underserved areas.

Appendix B

Biomedical Models and Resources: Current Needs and Future Opportunities

National Research Council
National Academy Press
Washington, D.C. 1998

EXECUTIVE SUMMARY

This report was produced at the request of the National Center for Research Resources (NCRR) and is based on the expertise and perspectives of the members of the NRC Committee on New and Emerging Models in Biomedical and Behavioral Research (biographical data are provided in Appendix B), on published data, and on information gathered by the committee through a survey and a workshop, discussions with other scientists, and the comments of those who reviewed the committee's draft report. This report addresses the role of the NCRR in supporting models for biomedical research and their related infrastructure. Accordingly, it is limited in scope and is intended to answer the following specific questions:

- What is NCRR's role in model development, support, and infrastructure?
- What can NCRR do that is unique and not likely to be undertaken by other NIH institutes?
- How should NCRR establish funding priorities?
- What criteria can NCRR use to set funding priorities?

The authors of this report considered mammals, nonmammalian terrestrial and aquatic vertebrates and invertebrates, and computer modeling

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systems of multisystemic—organisms. The committee recognized the importance of *in vitro* models, but did not cover them in this report for a variety of reasons detailed in the report. The authors of this report also studied model preservation and looked for evidence that useful animal models or strains had been lost because of a lack of financial support. The data and perspectives provided in this report represent the consensus of the committee and were derived from a survey of a cross-section of the scientific community, discussions with scientists in academe and industry (both those who receive NCRR support and those who do not), a workshop, and the committee members' own expertise.

Recurrent themes in all the sources of information on which this study drew were training of whole-animal scientists, improved methods and instrumentation for physiologic assessment, infrastructure for animal-based research, databases for phenotypic information, sophisticated computer programming to handle statistical analysis of complicated data and to model complex biologic systems, multidisciplinary approaches, and shared resources.

The committee found that expanded and stabilized competitive research funding would provide a better and more cost-effective infrastructure to enhance the utility and availability of animal models and the quality of animal-related research and laboratory animal welfare. Issues that need to be addressed include laboratory animal health and welfare (investigation of laboratory animal diseases, advanced diagnostics, and behavioral research); methods of animal acquisition, maintenance, propagation, and preservation; genetic maps of additional model species; advanced technology relevant to global National Institutes of Health (NIH) needs for animal modeling and animal-related research (such as methods for targeted mutagenesis, phenotype assessment, and so on); and alternatives to mammalian models or methods to reduce the need for them in research.

The failure of precision phenotyping to proceed at the same rate as genetic engineering and molecular technology has hampered the exploitation of genetically engineered model organisms. Reliable phenotype assessment was a need that arose repeatedly in the information that we gathered from all fields of research. The most common needs described were for accurate and reliable behavioral assessment, biotechnology development for physiologic assessment, pathologic assessment, and analysis of complex data.

For example, behavioral assessment in genetically engineered mice is a rapidly growing field of research. Yet many investigators entering the field are molecular biologists who know how to "knock out" genes but have little or no experience in behavioral assessment. There is frequently disagreement among laboratories about the meaning of results of particular tests. Some investigators use learning in the Morris water maze as a measure of spatial hippocampal learning; others disagree that the test clearly measures this aspect of learning. When investigators do use the same methods (such as the Morris water maze) to assess behavior and learning, they often fail to recognize the effect on experimental results of even small changes in test conditions. The test setup or details of the experimental protocol can vary greatly from one laboratory to another and produce different results that might reflect the experimental conditions rather than a biologic difference.

The trend toward study of complex diseases frequently requires that a scientist have access to expertise in various disciplines. The committee felt that some scientists might want to learn various disciplines but that many would benefit from access to shared resources that would provide the technology and expertise to assist in the analysis of complex phenotypes and disease issues. Such "foci of expertise" (whether physical or coordinated among different institutions) also would provide opportunities for scientists with different kinds of expertise to interact. They could be the catalyst for productive interdisciplinary collaborations. Foci of expertise could contribute to establishing a national network of integrative biology expertise.

Construction and renovation of animal facilities for the most widely used organisms (such as genetically engineered rodents) and emerging organisms (such as aquatic vertebrates and invertebrates) were found to constitute an infrastructure need that was important enough to set out by itself in the recommendations.

Because of trends toward model diversity, functional genomics, gene therapy, cancer biology, aging, infectious disease, neurobiology, and so on, there is a critical need to train scientists in whole-organism research. Furthermore, emphasis on animal-model research and concerns of society about humane use of animals mandate that NIH support scientifically based rationales for the humane and efficient management of laboratory animals and for dealing with their intercurrent diseases or special medical and husbandry needs. NCRR must train people to be able to handle the concepts of integrative biology to serve the NIH research mission. Broadening the training program would expand the comparative medicine scientific community, strengthen the comparative medicine academic infrastructure, and enlarge the body of scientists who can address the kinds of issues defined by this study.

The committee recognized that NCRR' s comparative medicine and biotechnology programs already have mechanisms in place to address many of the issues raised in this study. NCRR has programs for training future scientists how to work with animals; it already evaluates and funds animal facilities and disease research; it funds and provides to researchers the Guide for the Care and Use of Animals (NRC 1996a); it was a pioneer at NIH in recognizing the potential of nonmammalian systems; it funds technology development and large shared resources; and it is beginning to seek out and nourish projects with other government agencies and the private sector.

The recommendations listed below derive from the problems and opportunities uncovered by this study and can be addressed by expansion or modification of existing NCRR programs.

1. **NCRR should encourage and support research directed at improving research animal utility, availability, health, welfare, and maintenance.**

The committee, recognizing that science cannot be highly programmed supports the essential role of the peer-review process. Nevertheless, there is a need to improve technology that facilitates research and supports the discovery or creation of new models and the preservation of existing models. Some specific needs for increased support were identified: diagnosis and control of infectious disease; studies of animal behavior; improved animal acquisition, maintenance, and propagation; preservation of existing models and species; production of nonmouse gene maps; and development and miniaturization of instrumentation for physiologic measurements. Maintenance is important for model preservation and deserves careful consideration by NCRR.

2. **NCRR should create a national network of comparative medicine expertise**

   a. To support NIH research efforts on animal models, such as phenotypic and genotypic assessment and disease diagnostics.

   b. To promote multidisciplinary interaction.

Reliable phenotype assessment requires increased research on accurate and reliable behavioral assessment, new technology for physiologic and pathologic assessment, and new methods for analysis of complex data. The study of complex diseases will require that a scientist have access to expertise in various disciplines. To enhance phenotype assessment, development of multidisciplinary groups coupled with training programs in the various disciplines should be considered.

3. **NCRR should create a national network of integrative biology expertise that can serve the entire biomedical research community.**

The committee found that there is a need for experts in comparative medicine who are well trained in laboratory animal medicine and in research methodology as embodied in the concept of a comparative medicine biotechnology network. There is also a need for improved quantitative and mathematical modeling techniques that can be applied to biology. That will require efforts to encourage and facilitate interdisciplinary research programs; training of doctoral students, postdoctoral students, and scientists; development and dissemination of information technologies appropriate for biomedical applications; and development and maintenance of databases.

4. **NCRR should construct and renovate animal research facilities.**

Animal populations in the nation's research facilities are increasing substantially because of burgeoning mouse populations and the increasing emphasis on integrative biology with all types of models. The resulting crowding, coupled with increased interinstitutional traffic and diminished health surveillance and diagnostic support, has created dry tinder for devastating epizootics of infectious disease among irreplaceable animal colonies. Funding is urgently needed for new construction to expand animal holding capacity in many research institutions. Funding is also needed to build specialized animal holding facilities that can be shared by investigators who are using animal models, such as level 3 biocontainment facilities for infectious-disease research and facilities for unique species of animals not typically available to the biomedical research community, such as marine and aquatic animals. Such facilities fall within the realm of creating a network of facilities and expertise that support the national research effort.

5. **NCRR should reinvigorate and expand training opportunities in integrative biology.**

Because of trends toward model diversity, functional genomics, gene therapy, cancer biology, aging, infectious disease, neurobiology, and so on, there is a critical need to train comparative medicine scientists with whole-animal experience. Furthermore, emphasis on animal-model research and concerns of society about humane use of animals mandate that NIH support scientifically based rationales for the humane and efficient management of laboratory animals and for dealing with their intercurrent diseases or special medical and husbandry needs. NCRR must train people to be able to handle the concepts of comparative medicine to serve the NIH research mission. NCRR can foster critically needed laboratory animal residency training through the development of academic infrastructure. Veterinarians are an important, but not exclusive, component of the comparative medicine community, and NCRR research training should be expanded to encompass other disciplines that contribute substantially to mammalian and nonmammalian integrative biology, including comparative medicine, pathology, and physiology; biostatistics; mathematical modeling; and behavior.

6. **NCRR should obtain program guidance from the scientific community.**

Science is moving so rapidly that scientists cannot predict what disciplines or types of research will need models more than five years from now. NCRR must devise effective methods to monitor developing changes and be responsive to biomedical research needs. Two approaches can be effective: 1) improved use of existing methods, such as the Comparative Medicine Review Committee and staff participation in relevant workshops, scientific meetings, and retreats with scientific groups (like Gordon Conferences); and 2) the convening of periodic (every four years) independent advisory panels and small workshops to assess specific fields or asking independent agencies outside NIH to convene working groups to provide reports like this one.

To aid NCRR in setting priorities, the committee suggests the following criteria for assigning high priority to models and model support systems:

1. The model is appropriate for its intended use(s).
   a. A specific disease model faithfully mimics the human disease.
   b. A model system is appropriate for the human system being modeled.
2. The model can be developed, maintained, and provided at reasonable cost.
3. The model is of value to several scientists or for multiple purposes.
4. The model is reproducible and reliable, so results can be confirmed.
5. The model is reasonably available and accessible.

Appendix C

The Supply and Demand for Laboratory Animal Veterinarians from 1980 to 2005

B.J. Weigler, J.D. Thulin, S. Vandewoude, and T.L. Wolfle

ABSTRACT

We investigated the supply-demand relationship for laboratory animal veterinarians in the United States from 1980 through 2005,using results of 8 sub-studies that assessed the demographic profile of the workforce, Public Health Service funding for research involving animals, United States Department of Agriculture summaries of animal numbers used in research, trends in inflation-adjusted salary measures and the number of job advertisements over time, and statistically-based survey responses from laboratory animal veterinarians, their employers, and training program coordinators. Our results were consistent with the hypothesis that the marketplace for this specialty of veterinary medicine had entered a steady-state by 1995, in which the national demand for and supply of laboratory animal veterinarians were closely approximated. Evidence did not exist to suggest that this scenario would change dramatically between the years of 1995 and 2005. Analysis of the results of this study were in contrast with the less-optimistic economic forecasts for other sectors of veterinary medicine, physicians, and doctoral-level scientists. Economic assessments of the supply and demand for human resource services provided through the various veterinary medical specialties, including laboratory animal medicine, can offer valuable

Reprinted from B.J. Weigler, J.D. Thulin, S. Vandewoude, and T.L. Wolfe. 1997. The supply and demand for laboratory animal veterinarians from 1980 to 2005. Contemporary Topics in Laboratory Animals Science 36(2):39-46.

planning tools for use by veterinary leadership, members of the veterinary profession, and students deciding upon a career path in veterinary medicine, and should be rigorously undertaken and periodically re-examined by all sectors of the profession.

DISCUSSION

The study reported here used a diverse set of economic indicators related to the manpower supply-demand relationship, along with survey response data, to estimate the marketplace conditions for laboratory animal veterinarians in the United States. These indicators allowed for descriptive evaluation of trends in laboratory animal use, public health service funding relating to laboratory animal use, and demand for laboratory animal veterinarians on the basis of salary measures, classified advertisements, and the experiences and impressions of veterinarians, their employers, and training program directors. A demographic model of the laboratory animal veterinarian workforce was used along with training program information to forecast supply into the year 2005. None of these measures substantiated the hypothesis that a surplus of laboratory animal veterinarians currently exists in the United States. Rather, all available information suggested that the specialty has entered a steady state, whereby the number of laboratory animal veterinarians demanded is closely approximated by available supply, and the indications are that this condition will not change dramatically in the near future.

The marketplace for laboratory animal veterinarians enjoyed a period of apparent exponential growth during the late 1980's. Some of this growth coincided with new federal legislation governing the use of laboratory animals (16, 23), even though animal numbers and NIH funding for biomedical research did not increase commensurately (24). During that era, analysis of our data would suggest that the demand for board-certified laboratory animal veterinarian services shifted to a point beyond available supply, reflected in part by the increase in salaries during those years (Figure 8). In fact, other important economic factors also could have affected salary, such as the veterinarian's skill-class, possession of graduate degrees, and increased productivity for the institution as a result of employing such individuals. An increase in demand for veterinarians provided an economic incentive for the observed growth in the number of training programs and positions (Figure 3) reported for the same period. Federal funding for training programs remained constant at approximately 46% nationwide (Table 2), thereby helping to support the response in supply. The salaries and opportunities in this specialty probably attracted veterinarians into laboratory animal medicine directly from small animal practice (22) as well as those who entered through formal training program avenues.

The rate of growth in the specialty reached a plateau during the early 1990's, culminating in a relatively quiescent period during 1995. This lull in 1995 appeared to coincide with forces in the national economy, including trends to toward consolidation and downsizing of industry and widespread concerns regarding the future of biomedical research during a period of health reform. A gradual increase in the anticipated number of employment opportunities for laboratory animal veterinarians through 2005 (Figure 2) and stable amounts of PHS research funding, at least through 1997, should somewhat counter the' 1995 experience.

Another factor that will significantly affect marketplace dynamics in the years ahead is the current and projected age structure of the laboratory animal veterinarian workforce. Using our model, we demonstrated that the current workforce was predominantly < 45 years old, with relatively few people in the 46-55 age bracket (Figure 9). The current profile was consistent with an expansive-type structure (18), as the training program indicators would imply, suggesting that the workforce is undergoing a state of growth. This profile will evolve toward a stationary-type structure during the next decade (18), whereupon most age-classes will be well-represented. We estimated that an additional 170 workers soon will enter the' current workforce, resulting in an overall growth rate of approximately 20%. Extrapolating the net gain of 51 full-time positions (Figure 2) to the estimated number of employer groups using veterinarians nationwide (n = 536), we should see an additional 157 (95% CI = 113,201) laboratory animal veterinarian positions in the United States by the year 2005. The close agreement between these values supported the hypothesis of a steady-state condition, whereby supply and demand will be nearly in balance. However, deviations in the assumed retirement age of 65 years, attrition prior to retirement, or influx of veterinarians to the specialty at a rate beyond the current pattern could greatly affect this prediction.

Our finding differs substantially from the personal opinions of survey respondents. Although the vast majority (97%) of veterinarians surveyed presently were employed at least part-time, many (21%) felt that a surplus market already existed in 1995 and forecasted (50%) that this situation would soon worsen. Despite the current high employment rate for veterinarians in the specialty, these fears may have been supported by the perception that it has been increasingly difficult to find employment for themselves or their peers since 1980. Alternatively, these seemingly healthy employment statistics could have been biased, had most of the non-respondents been unemployed. If virtually none of the unemployed veterinarians responded to the survey, the random sampling design would imply that approximately 225 such individuals (25% of the list frame) existed in the United States during 1995, a scenario that is clearly known to be false. More likely, the economic transition from a situation in which demand overwhelmingly exceeded supply to the current steady state condition has brought with it the unfounded belief that the marketplace for laboratory animal veterinarians is nearing the point of saturation. This conclusion is supported by responses in the open comments section of the surveys, in which several respondents indicated that veterinarians are receiving fewer job offers than previously, that there are fewer jobs available now, and that many more-qualified professionals appear to be searching for their first or a new position in the field.

Additional concerns were raised regarding the perception that animal numbers used in research were decreasing, as were federal funds for research. Neither of these conclusions was substantiated by the present study, at least through the 1994 federal fiscal year. However, the NIH-CRISP database system probably overestimates the amount of PHS funding that actually involves animals, because the indexing system does not allow for evaluation of the extent of animal use per award. Thus, this database cannot differentiate awards that involve 10 mice from those that involve 500 monkeys, and both awards would be included in the dollar totals. Anecdotally, we are aware of several large academic institutions that have experienced a precipitous decrease in laboratory animal inventories during the past few years. Also, we underestimated the trend for total animal numbers used in research due to exclusion of rats, mice, and birds from USDA reports; however, this would only have increased estimates of veterinarian demand, to the extent that rodent use (especially for transgenic and immunodeficient strains) has reportedly been rising steadily for the past several years (25). If enforcement of the USDA Animal Welfare Act were extended to rats, mice, and birds, a significant increase in the demand for laboratory animal veterinary services would probably be seen across the United States.

A disturbing issue raised in the comments section was that of underemployment of laboratory animal veterinarians (i.e.. employment at a level below that of their skill level). Underemployment adversely affects salary and overall job satisfaction and is counter to the ACLAM 1993 Strategic Plan regarding research partnerships (26). Overall. ACLAM board-certification was the singularly most important credential for successful applicants, according to employers, whereas individual concerns were raised regarding perceived shortages of research-oriented, clinical-oriented, or administration-oriented laboratory animal veterinarians, depending on the circumstance. Some respondents cautioned that laboratory animal veterinarians should stay broadly trained to remain competitive in the changing marketplace. Increases in average salaries for ACLAM diplomates in real dollars (Figure 8) argues against the importance of a trend toward underemployment at present, although this issue should be closely monitored in the years ahead.

Along with ACLAM, training programs have played a cornerstone role in the evolution of the laboratory animal medical specialty in the United States. Excluding graduates of training programs that closed prior to 1995, at least 213 advanced academic degrees have been received by veterinarians enrolled in training programs since 1980 (Table 1). The research productivity from these accomplishments has increased the know1edge base of the profession and contributed toward the evolution of the specialty. Authority for training in academic laboratory animal medicine was granted to the Animal Resources Branch of NIH's Division of Research Resources in the mid-1960's (27). The NIH funding has long provided a considerable proportion of the support for academic training programs in laboratory animal medicine and comparative medicine, although recent indications are that this source will diminish substantially in the future (Table 2). Large-scale shrinkage or loss of training programs due to funding constraints will necessarily affect the supply of laboratory animal veterinarians, following a lag time equivalent to the duration for each program affected. The magnitude of the impact from such changes will depend on the proportion of total supply contributed via training program routes.

In the open comments section, some training program directors believed that the process of market retrenchment for laboratory animal veterinarians will continue over the next decade. Others suggested that highly-motivated and well-trained individuals will continue to be in high demand, regardless of the prevailing market conditions. Our study did not aim to determine the essential features of an ideal training program that maximizes the future marketability of its graduates. Overall, program directors reported that trainees were exposed to a wide-variety of skills and experiences deemed appropriate for postdoctoral training in this specialty (20), with substantial time allocated to research and didactic learning opportunities (Table 3). Attempts were not made in this analysis to distinguish the activity budgets of laboratory animal veterinarians in training by the source or extent of training program funding over time. Thus, conclusions cannot be drawn regarding the structure of training at programs supported partly through federal grants and contract, (n = 16 in 1995) versus those supported through other sources. Furthermore, due to the inherent diversity of job opportunities for laboratory animal veterinarians, it is difficult to directly correlate the training base with specific position requirements for all potential employers. In their open comments, employers indicated that good interpersonal skills and administrative experience, including fiscal management and knowledge of regulatory requirements, were highly desirable. In addition, some employers sought clinical expertise in certain species. such as rodent' or non-human primates, and many placed high value on the publication record and research abilities of applicants. General comments were received concerning a desire for candidates that had come from "good" training programs.

The study reported here was the first manpower study specifically directed at the laboratory animal veterinarian community in the United States, and, to our knowledge, the first such investigation for any of the veterinary specialties. The economic situation facing veterinary medicine today recently has been given much attention (3,5). Real starting salaries for veterinarian graduates entering private practice have not increased substantially since 1983, although the educational debt incurred by those graduates has increased substantially (4). Also, the ratio of the general population to the workforce of veterinarians in private practice has decreased by 5.4% since 1990, creating a possible imbalance in the potential for income growth in that sector (28). Economic surveys are limited in their ability to forecast the future because of unmeasured or unmeasurable changes in important related factors. We used a broad range of indicators to suggest the direction of trends for the laboratory animal veterinarian workforce in the coming decade. Our findings regarding the estimated rate of growth in this specialty substantially exceeded the predictions of Wise in which he conducted a survey of 115 private companies in 1984 (29). Whereas that report predicted a growth rate of 33% and 63% from 1984 to 1990 and to 2000, respectively, analysis of our results indicated that true growth rate was approximately 78% from 1984 to 1990, and may reach 125% for 1984 to 2000.

In contrast, our estimated growth rate of 142% from 1980 to 2000 for full-time laboratory animal veterinarians approximated predictions of Wise and Kushman (2), who expected gains ranging from 135% to 214% for the collective nonprivate veterinary sector under various supply-demand scenarios. However, that study also foresaw a continuing surplus of private practitioners to the year 2000 as well as decreasing private practice incomes under all scenarios. Neither of these predictions appears to have transpired to date. Similar surpluses were projected - in an earlier study by Arthur D. Little, Inc. (1), which estimated that 49,900 to 51,100 available veterinarians would exist in the United States by 1990. Although the actual national supply of 48,666 in 1990 (28) was close to that estimate, to date, a well-documented surplus has not been realized for the veterinary profession overall. Interestingly, that earlier study predicted that the supply of post-professionally trained veterinarians (including laboratory animal veterinarians) would approach the demand by 1990, and advised that training resources should be re-evaluated at that time.

Our data are consistent with a hypothesis that the marketplace for laboratory animal veterinarians is entering a steady state era in which supply and demand will be closely approximated over the next decade. This conclusion is much brighter than that forecasted for physician specialists (7,9) and for many doctoral-level scientists in other disciplines (10,11). Comparisons cannot be made with other specialty segments of veterinary medicine until similar studies are completed. If our predictions hold, this transition from a lengthy period of economic supply reactivity that result from demand-pull forces somewhat mirrors the biomedical research enterprise nationwide (24). Dr. Harold Varmus, Director of the NTH, believes that maintaining a healthy amount of competition in a steady-state world would only benefit scientific progress (24). Instead of reducing production of new graduates as some have suggested (11), he stated that training program should be resource-optimized and should provide for the diverse career options of future scientists. The breadth and depth of training in laboratory animal medicine inherently provides for employment opportunities beyond most of the veterinary profession, as the survey of our workforce has revealed. Nonetheless, the external forces shaping the new national economy are sufficiently large to argue against any decision to enter into a production-push mode through expansion of existing training programs in a manner independent of supply and demand factors. Lastly, it is notable that we have influence over our own destiny in the marketplace, to the extent that we embrace the ability to imagine and prepare for new opportunities in the vast dynamic arena of biomedical research. We have attempted to highlight some important economic issues currently facing the laboratory animal medicine profession, which we hope will stimulate continued investigations and discussions for this and other veterinary specialties in the years ahead.

Appendix D

Biographical Sketches of Committee Members

James Fox, DVM, MS is Director and Professor of Comparative Medicine and Bioengineering and Environmental Health at the Massachusetts Institute of Technology. He is a recognized expert on infectious diseases of the gastrointestinal tract and their oncogenic potential and is currently the principal investigator of three NIH RO1 grants. He administers the NIH-sponsored post-DVM training program in comparative medicine at MIT. He served on the Committee on Veterinary Medical Sciences in 1980-1982 to assess the effect of legislative and regulatory initiatives on the demand for veterinary medical scientists, an issue closely related to the current efforts. He was also the chair of the Committee for National Survey of Laboratory Animal Use, Facilities, and Resources.

John Harkness, DVM, MS, MEd is a professor in the College of Veterinary Medicine and University Laboratory Animal Veterinarian at Mississippi State University. He is an ad hoc consultant for the American Association of Assessment and Accreditation of Laboratory Animal Care, International, in which he served previously as a member of the Council on Accreditation for 8 years, including 3 years as chair or vice-chair. He served on the NRC Committee on Educational Programs in Laboratory Animal Science, and was a participant in the NRC workshop Definition of Pain and Distress and Reporting Requirements for Laboratory Animals.

William A. Hill, is a fourth-year veterinary medical student at North Carolina State University, pursuing a career in laboratory animal medicine. He received his bachelor's degree, summa cum laude, in Laboratory Animal Science from North Carolina Agricultural and Technical State University. Instrumental in reorganizing the Student Chapter of the American Society of Laboratory Animal Practitioners on his campus, he is also devising a survey instrument to be distributed to second-year veterinary students across the country to ascertain their motivation for careers in laboratory animal medicine.

Alan M. Kelly, BVSc, MRCVS, PhD is Professor of Pathology and Dean of the School of Veterinary Medicine at the University of Pennsylvania. His research interests include the development of neuromuscular specialization and muscular dystrophy.

Kathy Laber, DVM, MS is Associate Professor of Comparative Medicine, Veterinary Director of the VA Animal Research Facility and Administrative Vice-Chairman of the Division of Laboratory Animal Resources at the Medical University of South Carolina. She chairs an American College of Laboratory Animal Medicine committee on career pathways for laboratory animal veterinarians. Dr. Laber pursues collaborative research efforts in addition to her responsibilities for administering the Animal Research Facility. She is a diplomate of the American College of Laboratory Animal Medicine and a council member/assistant section leader of the American Association of Assessment and Accreditation of Laboratory Animal Care, International.

Fred Quimby, VMD, PhD is Associate Vice-President and Senior Director of Laboratory Animal Research Center at Rockefeller University and was previously a Full Professor of Pathology and held faculty appointments in the Graduate fields of Immunology, Environmental Toxicology and Veterinary Medicine as well as the Director of the Center for Laboratory Animal Resources at Cornell University. He administers the post-DVM training program in laboratory animal medicine at Rockefeller.

Abigail Smith, MPH, PhD is Director of Laboratory Animal Science, Animal Health, and Husbandry Research at The Jackson Laboratory. Her excellence in the field of laboratory animal medicine has been recognized with an honorary membership in the American College of Laboratory Animal Medicine. She has also been recognized by the American Committee on Laboratory Animal Diseases as an expert on the virology of laboratory rodents.

John Vandenbergh, PhD, is a Professor in the Department of Zoology, North Carolina State University, where he is an undergraduate advisor of pre-veterinary students. His research areas are environmental control of reproduction, the endocrine basis of behavior, and rodent and primate behavior. He was a member of the NRC Committee to Revise the *Guide for the Care and Use of Laboratory Animals,* Committee on Understanding the Biology of Sex and Gender Differences, and Committee on the Cost of and Payment for Animal Research.