

The Value of Biomedical Research Training for Veterinary Anatomic and Clinical Pathologists

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Abstract

Veterinary pathologists traditionally have been actively engaged in research as principal investigators and as collaborators. Pathologists frequently obtain advanced training in research; however, it appears that in the last 10 years there has been a reversal of a previous trend toward increasing numbers of pathologists obtaining PhD degrees. This has arisen despite an established shortage of veterinarians engaged in research. This article evaluates the benefits of research training for individual pathologists, including a wide spectrum of professional opportunities and additional skill development beyond that usually provided by diagnostic pathology training alone. Various training models are discussed, including combined and sequential diagnostic residency and research degree training as well as the nondegree research fellowship programs more commonly pursued in human medicine. Best-practice recommendations for program infrastructure, mentorship, time management, and a team approach to research and research training are advocated to facilitate the development of successful programs and to encourage a continued emphasis on integrated training for pathologists as both clinical diagnosticians and experimentalists. This article is intended to help prospective and active pathology trainees, their mentors, and educational administrators optimize opportunities to ensure the future vitality of veterinary pathologists, and their contributions, in basic and applied research.

Keywords

biomedical research, veterinary pathology, education, training, best practices

The 2005 National Academies of Science publication *Critical Needs for Research in Veterinary Science*¹⁰ documented a serious nationwide shortage of veterinarians engaged in biomedical research (http://www.nap.edu/catalog.php?record_id=11366). Historically, veterinary pathologists have played a key role as scientific investigators in addition to their contributions as diagnostic pathologists, teachers, and research collaborators, which is why research is considered to be a crucial element of best practices in pathology training.⁵ Integration of research training with a clinical perspective has strengthened the pivotal role of veterinary pathologists in these endeavors. Unpublished data obtained from the American College of Veterinary Pathologists (ACVP) suggest that from 1950 to 2000 there was a slow but incremental increase in the numbers of diplomates earning PhD degrees; however, that number decreased for diplomates in the 2000–2010 cohort, despite calls for an increase in veterinarians with research training. This decrease not only will negatively affect the profession and biomedical research in general but will limit opportunities for individual pathologists without research experience. Veterinary anatomic and clinical pathologists have a broad understanding of comparative biology and medicine that uniquely facilitates a comprehensive

and innovative approach to complex research problems. Full engagement in research topics also requires maintaining and developing up-to-date expertise in areas such as molecular pathology and study design and methods. The ability to optimally leverage research conducted using both experimental and spontaneous animal models of human disease for translational purposes requires individuals with the aforementioned skill set. For veterinary pathologists to continue to make critical contributions to biomedical research and collaborative efforts

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such as the One Health Initiative, it will be important for the discipline to increase the number of pathologists who have the knowledge and skills to function as primary investigators as well as collaborative researchers. This document, which uses a best-practices approach and complements the "Elements of Good Training in Anatomic Pathology"⁵ and similar guidelines in veterinary clinical pathology, presents the advantages of research training for pathologists and describes different models for pursuing research training while addressing factors that may influence trainee choices.^{3,8} The goal is to provide trainees and training institutions with discussion points to support efforts by our specialty college to prepare new pathologists for rewarding careers as primary investigators and collaborative researchers. Regardless of area of career concentration chosen by the individual pathologist, investigative skills acquired during research training will translate to problem-solving abilities benefiting experimental and/or clinical diagnostic responsibilities.

Benefits of Research Training for the Pathologist

Widest Spectrum of Job Opportunities and Potential for Crafting Responsibilities to Satisfy Personal Career Interests

The 2008 ACVP Demographic Survey indicated that more than one-third of employers considered research training an important requirement, whereas only 24% considered such training unimportant. In a competitive job market, diversification of skills allows for a greater breadth of opportunities for employment and greater variety in day-to-day responsibilities. Veterinary pathologists with research training are far more likely to be leaders or key members of research teams in academia, industry, or government. These investigative teams tackle a wide range of critical problems in basic science research, translational medicine, public health, and ecosystem management and conservation.⁶ Veterinary pathologists trained in research are exquisitely positioned to facilitate translational research as a result of a comparative orientation to problem solving across multiple species, a multisystemic orientation to pathophysiology, and fluency in vocabularies of the clinician and basic scientist. Both public and private research sponsors emphasize the importance of rapid translation of basic research findings to the clinic, with animal research being a critical link in that process. There is a high demand for veterinary pathologists with research training to evaluate safety and efficacy of new tests and treatments in animal models, including bringing these advancements into human veterinary and human medical practice in the form of clinical trials. Veterinary pathologists with research training also are valued in public and private sector positions because of their unique ability to develop animal models, often initially recognized in companion animals with spontaneous disease. For example, dogs are valued as models of cancer biology and neurological disease because of the availability of inbred strains (breeds), increasing availability of genetic information, and their cohabitation of the human environment.⁹

Skill Development

The value of and several mechanisms for obtaining research training have been discussed previously in the larger context of best practices for pathology residency training.⁵ Research training provides a unique opportunity for developing critical thinking and problem-solving skills; learning laboratory methods and experimental design in the context of hypothesis-driven experimentation; enhancing knowledge of disease and normal biology; evaluating safety and efficacy of new pharmaceuticals; designing new biomedical devices, diagnostic tests, and instruments; contributing to drug discovery; and developing and evaluating new teaching strategies. Whether one will find research appealing is assuredly not intuitive. Fascination more often follows one or more experiences in conducting research or otherwise participating in the scientific method. It may prove to be valuable for pathology training programs to expose pathology residents to research and other investigative techniques during residency training as a means to stimulate further interest and to provide residents with the confidence to make a decision to pursue research training beyond or during their residency. Whereas the primary focus of residency training is the mastery of what is known, the goal of research training is discovery of the unknown. Research trainees learn to identify and define a significant problem, generate a testable hypothesis, design appropriate experiments to test that hypothesis, learn or develop laboratory methods, properly analyze large and complex data sets with appropriate statistics, and clearly communicate results that support or refute the hypothesis. In addition, research trainees learn how to manage a long-term project, follow a budget, and write and speak clearly to a wide variety of audiences. This investigative process fosters the development of highly trained veterinary pathologists who can contribute as independent and/or collaborative researchers in a wide variety of scientific endeavors. Possibilities range from subcellular molecular mechanisms of disease to whole animal and ecosystem biology that encompass basic, translational, and clinical research, benefiting animal and human health. In many cases the skills developed during research training are complementary to those developed during residency programs, allowing for the pursuit of combined programs or relatively smooth transitions for trainees opting for sequential training. Review of the recommendations for the elements of good training in pathology reveals that research training reinforces and augments foundational scientific knowledge and investigative and communication skills developed during the residency.^{3-5,8} Although some aspects of research training may be specific for a particular type of job, most of the critical thinking skills acquired during a rigorous research program are applicable to a wide variety of pathology careers.

Personal Choice and Satisfaction

Trainees pursue research training in addition to a pathology residency for a variety of reasons including an innate curiosity and a yearning to generate new knowledge, an attraction to

problem solving and troubleshooting, a motivation to be creative and work at the cutting edge, a desire for more comprehensive understanding of pathological processes and mechanisms of disease, and a recognition that a more diversified skill set enables them to compete for a wider range of professional opportunities. Renewed emphasis on the ancient connections between human, animal, and ecological health empowers research veterinarians to tackle global problems in concrete ways that reward the years invested in training. Presentation of new knowledge at national and international meetings provides opportunities for travel and engagement with colleagues around the world. Many research jobs include the opportunities for sabbaticals, with additional travel options and ongoing personal and professional development. Although undoubtedly demanding, careers in research can offer flexible schedules and excellent benefits to facilitate work–life balance.

Models for Research Training Programs

Current models for dual training in pathology and research include a combined residency/PhD program and sequential training. In combined programs, pathology training typically occurs in parallel with research training or residency followed by a PhD or vice versa. Alternative options include a master's degree (or equivalent) or experience in nondegree fellowship training. Each has its advantages and disadvantages but ultimately enhances the competence of the pathologist.

Combined programs have the advantage of geographic stability and increased efficiency if pathology and research training can be optimized through synergies between the research project and pathology training. This requires clear communication and close collaboration among the trainee and the primary clinical and research mentors and a critical balance between learning pathology and performing research, which may not suit the learning style of some trainees or the institutional culture in some academic centers.

In sequential programs, pathology training and research training occur serially. In this type of training environment, the trainee should consider the order of the program of study. If pathology training is completed first, the trainee and mentors should consider mechanisms to maintain diagnostic skills during the research program, whereas if research training occurs first, attention should be given to maintaining scientific momentum and research expertise during pathology training. In either case, mentors and trainees must work together in optimizing and timing the completion of qualifying benchmarks such as board certification by the ACVP.

As an alternate to these more conventional models, training programs should consider the nondegree fellowship model for research training similar to that commonly followed in human medicine. In these types of fellowships, pathologists work with established researchers for a specified amount of time to develop research skills with competence evidenced by successful, high-quality publications and independent funding with variable but modest amounts of time devoted to maintaining diagnostic skills. New collaborative models may involve

interinstitutional programs or interactions between public and private institutions to increase the breadth of expertise of mentors, the variety of projects, and resources for training, all of which have the potential to improve the quality and quantity of training programs.⁷

Recommendations for Best Practices

Although these recommendations for best practices speak primarily to mentors and program directors, trainees should also be sensitive to programmatic features such as infrastructure and availability and quality of mentorship prior to choosing a program. Likewise, these recommendations may serve as discussion points for programmatic improvement. Several factors are critical for the success of programs to train veterinary pathologists in research. These include a selection process that carefully matches the trainee with the best program for that particular student; adequate infrastructure that includes facilities, funding, and administrative support; and enthusiastic, supportive mentors willing to balance other career responsibilities with the time and effort required to be an effective mentor. Careful consideration should be given to the very real contemporary concerns that influence the decision to pursue research training in parallel with or in sequence to a pathology residency, including extended time in training, educational debt, and career track expectations of veterinary graduates.^{1,2}

Program infrastructure. Infrastructure includes access to equipment and technical and clerical support as well as stable funding with reasonable salary scales and deferrals or forgiveness for educational debt. Institutions with strong research programs can provide financial resources for trainee salaries and educational fees through competitive training grants, investigator grants, or endowments. Benefits packages should be appropriate for adult learners who may have responsibility for family members. Clearly, communicated and supportive policies for parental leave and elder care will facilitate completion of combined or sequential training. To address the concerns of trainees engaged in sequential training, there should be opportunities for maintaining either diagnostic expertise or research scholarship while the trainee is engaged in the complementary program. For example, access to regular rounds or seminars, scheduled reading time for pathology journals, intermittent pathology duty, and attendance at regional or national pathology conferences help to maintain diagnostic pathology skills while in research training, whereas attendance at research seminars and continuation of more limited investigations or collaborative projects during the residency years help to maintain research productivity during diagnostic pathology training.

When considering a doctoral degree program, trainees should meet with potential mentors regarding the ongoing projects in their laboratory, their philosophy of mentoring, and options for research funding. Trainees should seek information from current and former graduate students in potential research laboratories and should be encouraged to investigate options at other sites, both nationally and internationally, to gain

perspective from other environments. After the trainee selects a research project and major advisor, a PhD advisory committee should be assembled that includes the major professor and other faculty members whose expertise is closely aligned with the PhD project. The trainee should meet regularly with this committee to ensure the quality of the project, obtain guidance on the design and scope of the research, get help with interpretation of results and manuscript preparation, and acquire an ongoing assessment of his or her progress. Program administrators are encouraged to develop formal procedures for regular evaluation of progress throughout the program that include typical time frames for benchmarks such as completion of required coursework, preliminary examinations, and planning for the final defense. Programs are also encouraged to self-evaluate through a process of regular opportunities for formative program assessments by the trainees, exit interviews, and mechanisms for outcomes assessment of program goals.

Trainees should examine a variety of programs at multiple institutions, including programs of comparative medicine at medical schools and other academic units outside of veterinary colleges such as comprehensive cancer centers that support interdisciplinary research well suited to veterinary pathologists. Research training collaborations among universities or between universities and industrial or governmental institutions should be initiated. Pathologists in pharmaceutical or biotechnology research and development could play a much larger role in research training in the future. Trainees would benefit not only from research experiences and access to state-of-the-art equipment at these institutions but also from witnessing more diverse career opportunities in research other than academia.

Mentors. Availability of enthusiastic, supportive mentors is a key factor in the success of combined and sequential research training programs as it is for training in diagnostic pathology.⁵ There should be a variety of laboratories characterized by research excellence and a critical mass of diverse faculty willing to serve on graduate studies committees. Institutions with enough faculty to support diagnostic services and independent research programs are better positioned to provide the breadth of mentoring needed to support graduate students in these rigorous programs. There should be opportunities for mentors to improve their mentoring skills, and there should be clearly communicated mechanisms for support when issues arise between mentors and trainees. Mentors must have enough time to devote to mentoring, and trainees must have enough time to maintain work–life balance. In academic institutions, faculty time for mentoring could be protected by providing novel approaches to meet institutional needs for other faculty responsibilities. In addition to residency mentors and traditional research committees, additional supportive role models and resources may be helpful to address management of work–life balance, family challenges, and issues related to professional development and career planning.

Time. Time is a critical factor for most students, and every effort should be made to design efficient courses of study.

Individualized curricula should strike a balance between supportive didactic coursework and research time. With most trainees having completed veterinary degrees as well as a number of graduate-level courses, it is likely that few additional didactic courses are necessary, and these should be held to a minimum. Economies in the total time in training can be achieved if departments work with graduate schools to update curricula for these specialized research-training programs for veterinarians. It is recognized that in many combined pathology programs, coursework partly serves for further preparation in diagnostic pathology. Careful planning, regular meetings between trainees and mentors, and clear performance targets with supporting written documentation should allow reasonable time frames for completion of training. A clear understanding of shared goals for the institution, mentors, and trainees and a sense of community will support trainees through the challenges of rigorous but ultimately rewarding programs. For trainees, flexible schedules and programmed time for at least 2 weeks of vacation per year are essential.

Preparing for a research career. The development of an independent research program has historically been the model expectation for pathologists conducting research in academic settings. However, research conducted by multidisciplinary teams to which the veterinary pathologist makes unique contributions is increasing. Veterinary pathologists play key roles in multidisciplinary research teams, providing a broad understanding between basic and clinical sciences. This team approach often includes preparing successful grants, performing experiments, and disseminating results. Likewise, research in the private sector often includes a multidisciplinary or team approach. Although budgets may be negotiated in the context of other competing projects, formal competitive grant writing is minimal in some settings. Any career in the medical sciences is expected to be demanding; however, the diversity of opportunities for veterinary pathologists with research training allows for each individual to find her or his best fit within the profession to balance the rewards and challenges of this exciting field.

Summary

Historically, most veterinary pathologists have acquired both pathology and experimental research training in their backgrounds, and this has greatly influenced the accomplishments and stature of the discipline. This theme is worth continued emphasis. Trainees are vested with significant responsibilities for their own success in training, just as they will be responsible for success in their subsequent careers. Regardless of precisely how training as an experimentalist is acquired, the value stems from obtaining a mentored, focused experience in research in an environment where a critical mass of other trainees and sufficient resources for the conduct of research are in place. Ideally, the objectives should include developing expertise and reputation in a field while building a pathway to independent investigative ability and the production of high-quality peer-

Table 1. Examples of Research Training Fellowship Funding Opportunities Available to Veterinary Pathologists

Source	Website
National Institutes of Health Institutional Training Grants (T32)	http://www.ncrr.nih.gov/comparative_medicine/resource_directory/training.asp
National Institutes of Health Postdoctoral Fellowships (F32)	http://www.niehs.nih.gov/careers/research/trainingfrom/fellowships/f32.cfm
National Science Foundation	http://www.nsfgrfp.org/
Pfizer Animal Health–Morris Animal Foundation Veterinary Fellowships for Advanced Study	http://www.morrisanimalfoundation.org/professionals/veterinary-fellowships-for-advanced-study/
Morris Animal Foundation Fellowships	http://www.morrisanimalfoundation.org/professionals/scientists/
ACVP/STP Coalition for Veterinary Pathology Fellows	http://www.vetpathcoalition.org/

reviewed publications in journals of significant impact. Research training enables veterinary pathologists to be more competitive for most professional positions and enriches their work experiences regardless of the ultimate career pathway. Research training will continue to enhance our ability to interact with the larger biomedical community, maintain our role in advancing biology and medicine, and remain relevant in the world of global health. Given the significance of animals as potential sources of zoonotic disease or novel infectious agents and the reliance on information from animal studies for major medical advances, comprehensively trained veterinary pathologists will continue to be critical to the design and interpretation of research studies. As in the past, some pathologists will focus their careers on research as principal investigators, but many pathologists will continue to seek a career that includes both research and diagnostic pathology. Trainees are encouraged to consider the personal and professional value of research training as being equal to or greater than the necessary investment both for their own careers and for veterinary medicine and global health. In turn, mentors and training institutions should engage in continual reflection on mechanisms for optimization of educational programs listed in Table 1.

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