

College of Veterinary Medicine, Department of Veterinary Biosciences

# Veterinary Pathology Residency Training and Graduate Education in Veterinary & Comparative Medicine

The Ohio State University

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**Veterinary Pathology Residency Training and Graduate Education in  
Veterinary & Comparative Medicine  
Department of Veterinary Biosciences  
College of Veterinary Medicine  
The Ohio State University**

**Summer 2019**

**A) General Description of Training Program:**

The Ohio State University (OSU) Department of Veterinary Biosciences (VBS) is one of three departments in the College of Veterinary Medicine (CVM), an important component of one of the most comprehensive health sciences centers in America. The department has a long and successful track record of training research pathologists, incorporating elements of both veterinary pathology residency training and graduate education in Veterinary & Comparative Medicine into a seamless program. Specialty training is offered in veterinary clinical and anatomic pathology, with both courses of study being similarly structured. In the **first year, the program is pathology intensive**, and instruction is based upon service activities, didactic coursework, and participation in regular seminar series. Approximately 10% effort is devoted to the identification of laboratories in which to pursue graduate education leading to the PhD degree. **Years two through five are research intensive**. Students engage in dissertation research, participate in scientific meetings, workshops, and seminar series that hone their skills as investigators in biomedical research. The program is designed to promote development of both written and verbal communication skills that are essential for pathologists in all career paths. Success in the research arena is reflected in the quantity and quality of student first-authored publications and extramurally-funded fellowships. Pathology training continues after the first year in the form of more flexible service-related activities (e.g., reading surgical biopsies in lieu of participation in autopsy rotations; cytopathology service), selected didactic coursework and participation in a wide variety of regularly scheduled pathology seminars. Trainees are encouraged to coordinate Phase I of the American College of Veterinary Pathologists (ACVP) Board Certification Examination with the PhD candidacy examination (typically scheduled at the end of the second year in the program). Preparation for Phase II of the ACVP Board Certification Examination generally begins in the fifth year of the program, as the dissertation draws to completion, and follows a carefully structured regimen that takes advantage of the large group of residents in VBS; individuals typically prepare in groups, maximizing the economy of effort on behalf of both the student and faculty mentors.

As noted in the 2007 review of the department by the Office of Academic Affairs at The Ohio State University, “VBS is unquestionably recognized as amongst the very best programs of its type at both the national and international levels.” In addition, upon a previous university wide assessment of 87 doctoral programs, the doctoral program in VBS was one of only 12 receiving the highest ranking, awarded to programs recognized as outstanding in terms of overall quality, planning, focus, and potential to enhance the standing of the university.

In 2012, a college-wide graduate program in Comparative & Veterinary Medicine was modeled on the successful VBS program. There are approximately 163 graduate faculty affiliated in the **CVM Comparative & Veterinary Medicine Graduate Program**. These faculty include those who are primarily appointed across the three departments in the College of Veterinary Medicine as well those from other Colleges such as Medicine and Pharmacy. The **Council for Graduate Studies** (CFGS) is a standing CVM committee charged with formulating, communicating and implementing policies and procedures to promote graduate education within the CVM leading to the MS and PhD. The CFGS has strong VBS faculty and staff representation including the Chair (Dr. La Perle), two faculty members (Drs. Cornet-Boyaka and Oglesbee) and the Associate Dean for Research and Graduate Education (Dr. Green). A standing VBS committee, the **Combined Pathology Residency/Graduate Studies Committee**, also exists to ensure balance in pathology residency training and graduate education, as well as the timely completion of the PhD and success on the ACVP Board Certification Examination. The committee consists of: the 3 VBS faculty CFGS members; the Anatomic Pathology Training Coordinator and Combined Residency/PhD Program Co-Director (Dr. La Perle); the Clinical Pathology Training Coordinator and Combined Residency/PhD Program Co-Director (Dr. Jessica Hokamp); the Program Coordinator (Ms. Shannon Binkley); and, a Student Representative. VBS-affiliated graduate faculty are primarily focused in three major areas of research: infectious disease/immunology; oncology/cancer genetics; and pathophysiology/pharmacology. All laboratories supporting dissertation research are extramurally funded, with the majority of that funding coming from the National Institutes of Health. Research projects performed in these environments necessarily embrace state-of-the-art technologies in genomics and proteomics (and other –omics technologies) and development and use of animal models, including but not limited to genetically modified mice.

## **B) Curriculum:**

Principles of general pathology, comparative pathology of naturally occurring diseases of humans and other animals, and introductory training in toxicological pathology are presented in both didactic and seminar course series:

### **Veterinary Biosciences (VBS) 8810-8815 - Advanced Systemic Pathology**

This didactic course series is a foundation for all anatomic pathology residents and recommended for clinical pathology residents. A systems-based approach is used to discuss mechanisms of disease at the biochemical, cellular, tissue, and organismal level. Emphasis is placed upon naturally-occurring diseases. Experimentally-induced disease is presented when it serves to elucidate mechanisms relevant to other disease processes. The approach is comparative medicine-based, focusing upon diseases of mammals. The course of study spans two years and is team taught. Faculty participation is based upon either general, organ system-specific or species-specific pathology expertise. Additional instruction is provided by specialists from regional academic institutions and industry. Lectures are supplemented with faculty-mentored reviews of histopathology, hematology, cytology and ultrastructural pathology study sets.

**VBS 8810 (Spring Semester):** Pathology of laboratory animals including mice, rats, hamsters, gerbils, guinea pigs, rabbits, non-human primates, *Xenopus* spp. and zebrafish, as well as zoo and wildlife species.

**VBS 8811 (Fall Semester):** Pathology of the reproductive, endocrine, ophthalmic and cardiovascular systems.

**VBS 8812 (Spring Semester):** Pathology of the hepatobiliary, dermatologic and gastrointestinal systems.

**VBS 8813 (Fall Semester):** Pathology of the respiratory, nervous and musculoskeletal systems.

**VBS 8814 (May Session):** Pathology of the hemic-lymphatic system.

**VBS 8815 (May Session):** Pathology of the urinary system.

#### **VBS 8895.03 - Seminars in Veterinary Clinical Pathology**

This is a weekly seminar focused on discussion of clinical cases, current advances in the field, and laboratory consideration that may include quality assurance, generation of reference intervals, and test validation. Clinical pathology faculty and residents rotate as conveners for this course. There is a mini mock board examination at the end of each semester. The seminar is a fundamental activity for clinical pathology residents, with student enrollment occurring from the beginning through the end of the training program.

#### **VBS 8895.04 – Histopathology Seminar**

This is a weekly seminar using histopathology (both light microscopic and ultrastructural) and/or clinical pathology case-based materials to discuss mechanisms of disease or patterns of disease expression. Anatomic and clinical pathology faculty, students, and pathologists from outside the university rotate as moderators for this course. The seminar is a fundamental activity for anatomic pathology training, with student enrollment occurring from the beginning through the end of the training program. Selected participation by clinical pathology residents is recommended as preparation for the ACVP examination as well as application in research laboratories.

#### **VBS 8895.02 - Seminars in Diagnostic Veterinary Medicine**

This course is a series of monthly conferences that include cardiac, dermatologic, gross, laboratory animal, large animal, neurologic (brain trim), oncologic, ophthalmic and zoo pathology. Conferences are multidisciplinary in nature, with participants including both clinical and pathology faculty, residents, and students. Pathology residents work with senior pathologists to prepare case presentations, with a goal of integrating clinical findings (e.g., MRI results, CSF cytology results) to gross and microscopic post mortem findings. Students are formally enrolled in the course during pre-candidacy exam semesters; although participation in conferences continues throughout the program as an invaluable learning opportunity.

Three additional courses use a case-based approach to instruction in gross post mortem findings, histological findings, and cytological interpretation of clinical specimens. Instruction is linked to

autopsy, surgical biopsy, and cytology services. Residents are responsible for generating final written reports and communicating with clinicians and/or owners under the guidance of a senior faculty board-certified pathologist.

**VBS 8893.01 – Applied Comparative Pathology**

This course covers activities of first year anatomic pathology residents engaged in autopsy rotations.

**VBS 8893.02 - Veterinary Surgical Pathology**

This course covers activities of 2nd through fifth year anatomic pathology residents engaged in the interpretation of surgical biopsies.

**VBS 8739 – Specialty Training in Clinical Pathology**

This course covers activities of clinical pathology residents engaged in the interpretation of cytology, hematology, and serology findings.

A graduate level course in statistics is required of all residents, representing a minimum of three credit hours. Students may select from a number of courses offered, the choice being determined by the student's background and interests. Individuals with a statistics background from their undergraduate or prior graduate curriculum can also fulfill the requirement by enrolling in one of a number of summer programs in applied statistical methods, these being workshops offered by the Statistics Department. Statistics course offerings are as follows:

**Veterinary Clinical Sciences (VCS) 8783 & 8784 – Experimental Design & Data Analysis in Veterinary & Comparative Medicine I and II**

**Molecular Genetics 5650 - Analysis and Interpretation of Biological Data**

**Statistics 6410 - Design and Analysis of Experiments**

**Statistics 5301 & 5302 – Intermediate Data Analysis I and II**

Instruction in biomedical ethics is required of all students in the combined program, as one of the learning objectives of our graduate program, and being a requirement for individuals engaged in projects funded by the National Institutes of Health. Course offerings in this area are as follows:

**Completion of the CITI Online RCR Training course.**

<http://orpp.osu.edu/irb/training-requirements/citi/citiinstructions/> This online course covers all federally required topics; may take up to 4 hours depending on knowledge base; can start and stop as necessary; and completion is recorded by OSU. Frequency: Need only be taken once during the training program.

**Pharmacy 8520 – Research Ethics; 1 unit, S/U**

**Education and Human Ecology 8000 – Responsible Conduct of Research; 1 unit, S/U**

**MedColl 5000 – Responsible Conduct of Research and Research Ethics; 1 unit, S/U**

**Biomed Engineering 6983 – Research Ethics; 2 units, graded**

- Chemistry 6782** – Ethics in Scientific Research; 1 unit, S/U
- Nursing 7781** – Responsible Conduct of Research; 3 units, graded – ONLINE
- Vision Science 7960** – Ethics in Biomedical Research; 2 units, graded
- Bioethics 6010** – Biomedical Research Ethics; 3 units, graded – ONLINE
- Surgery 8814** – Responsible Conduct of Research: Human Participants and Use of Animals in Biomedical Research; 2 units, graded

The graduate curriculum supporting research training is highly flexible, being tailored to the student's background and specific research interest. Additional coursework is defined following formation of and consultation with individual graduate advisory committees, being tailored to the project and needs of the student.

### C) Development of Oral and Written Communication Skills

A fundamental component of the graduate education is the presentation and publication of research findings. This begins with the requirement for formal presentations in the Comparative and Veterinary Medicine Student Research Seminar (VPM 8891) which exposes trainees to the wide variety of research that occurs within the department, college, university health sciences center, and the Research Institute at Nationwide Children’s Hospital, in addition to work by OSU collaborators from other institutions. Students receive critical feedback for their seminar presentations in order to hone their presentation skills.

Students are expected to publish results of their research in peer-reviewed journals, with one first author paper accepted, in press or published as one requirement to graduate with a PhD. The model dissertation is composed of five publishable chapters. At the time of graduation, the average student will have multiple publications in various stages of publication (published, in review, and in preparation).

It is anticipated that most students will submit applications for fellowship support. This exercise hones scientific writing skills and has obvious economic benefits for both student and mentor. A summary of extramural awards for graduate education since 1990 follows:

<u>Number</u>	<u>Award Mechanism</u>
11	NIH K08 (Mentored Clinical Scientist Development Award)
11	NIH K01 (Special Emphasis Research Career Award)
13	NIH F32 (Individual National Research Service Award)
37	NIH T32 (Institutional National Research Service Award)
1	NIH TL1 (Institutional Clinical and Translational Science Award)
1	HHMI Med into Grad Fellowship
2	Fulbright Fellowship
5	ACVP/STP Coalition
1	Genentech Veterinary Pathology Fellowship
2	Eli Lilly Fellowship
3	U.S. Army Scholarship/Postdoctoral Res. Fellowship
2	U.S Department of Defense Fellowship

1	National Multiple Sclerosis Society
1	American Heart Association Fellowship
1	IDEXX Fellowship
1	Osteogenesis Imperfecta Fellowship

Most importantly, students present results of their work at national and international meetings. Overall quality of student presentations is reflected in awards to our trainees distributed at the annual meetings of scientific and professional societies such as the American College of Veterinary Pathologists (ACVP), American Society for Veterinary Clinical Pathology (ASVCP) and the Society for Toxicologic Pathology (STP). In addition to travel and young investigator awards, our trainees are competitive for national awards and fellowships including but not limited to:

- **Harold W. Casey Scholarship Award:** recognizes and rewards an outstanding individual training in veterinary pathology and striving to achieve ACVP certification: 11 awardees since it was started in 1994.
- **IATP/STP Charles Capen Trainee Award:** recognizes a published manuscript from a peer reviewed journal consisting of original work involving clinical or experimental research that relates to toxicologic pathology. 2018 Awardee, Dr. Rebecca Kohnken.
- **Daniel Morton and Laura Dill Morton Scholarship:** established in 2016 to recognize an outstanding student/trainee with an interest in toxicologic pathology. 2017 (Dr. Elizabeth Clark) and 2019 (Dr. Tim Helms) awardees.
- **NIH Loan Repayment Program Awards:** established to recruit and retain highly qualified health professionals into biomedical research careers by repaying up to \$35,000 annually of a researcher's qualified educational debt in return for a commitment to engage in NIH mission-relevant research. Awarded to 9 trainees since 2007

#### **D) Interactions with other Training Environments:**

The Ohio State University is one of the top ten public research institutions in the country, with one of the largest Health Sciences Centers. The latter is composed of the Colleges of Medicine, Veterinary Medicine, Pharmacy, Dentistry, Nursing, Optometry, and Allied Medical Professions. All components of this center are on the same campus and within walking distance of the College of Veterinary Medicine. In addition, The Research Institute at Nationwide Children's Hospital is a ten minute drive from the department. This environment is key to our training by providing a limitless source of multidisciplinary graduate faculty that are members of research centers, shared resources providing state of the art instrumentation and support services, and seminar series that engage internationally recognized scholars from within and external to the university.

The **Retrovirus Research Program** at OSU was organized in the early 1970s with funds from the National Institutes of Health (NIH) Special Cancer Virus Research Program. In 1989, OSU

designated the Retrovirus Research Program as a university academic Center of Excellence. The center's mission is to facilitate interdisciplinary research among faculty, graduate students and post-doctoral scientists in their investigations of problems relating to the prevention and treatment of retrovirus diseases of animals and man. As part of this mission, the Retrovirus Research Program and the **Center for Retrovirus Research** have initiated more than 60 extramural projects pertaining to the pathobiology of retrovirus-associated diseases over the past 30 years. On behalf of center members, the university has been awarded extramural research support from the NIH, Department of Defense (DOD), and private foundations and companies. The pioneering research that led to the development of the feline retrovirus vaccine at The Ohio State University was sponsored by extramural research dollars. An additional \$14 million of unencumbered royalties have come to the university from the sales of the vaccine (LeukocellR) licensed to Pfizer Animal Health. Under the direction of Patrick Green, PhD, membership includes 20 principal investigators at OSU, Nationwide Children's Hospital Research Institute and Wright State University. The research interests of center members are diverse and form a highly interdisciplinary network of collaboration for research initiatives. Research disciplines include virology, pathology, immunology, cell biology, molecular biology, endocrinology, neurology, pharmacology, biochemistry, and infectious diseases. This multi-disciplinary composition enables researchers to design and develop comprehensive research studies on retrovirus diseases and related topics that would not be possible by individual laboratories.

As one of only 70 designated comprehensive cancer centers in the nation, The Ohio State University **Comprehensive Cancer Center** – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute, is dedicated to the creation of knowledge in laboratory, clinical and population-based cancer research, and the development of more effective approaches to cancer prevention, diagnosis and therapies – providing tomorrow's standard of care, today. Under the direction of Raphael Pollock, MD, PhD, Ohio State's cancer program includes 5 highly interactive cancer research programs with more than 340 scientists from 11 of the 15 colleges at The Ohio State University and affiliated institutions. Together, these 5 programs span basic science to clinical trials. Supporting these research programs are 21 state of the art Shared Resources that are laboratory, clinical and population-based. During the last several years, research programs have continued to grow in scientific and clinical strength through recruitment and retention of some of the world's brightest minds in cancer research. A clear focus on translational research and the funding of state-of-the-art technologies have enhanced the quality of science and the progress toward discoveries. These programs include: Cancer Control; Leukemia Research; Molecular Biology and Cancer Genetics; Molecular Carcinogenesis and Chemoprevention; and, Translational Therapeutics.

**The Center for Clinical and Translational Science (CCTS)** was established at OSU through a **Clinical and Translational Science Award (CTSA)** from the National Institutes of Health. The award provides support services to Ohio State researchers while fostering collaboration with other medical centers that are recipients of the grants. This NIH grant marks a new era in collaboration internally and externally, enabling research and clinical trials to be quickly translated into treatments benefiting patients and the entire community. Under the direction of Rebecca Jackson, MD, Associate Dean for Clinical Research in the College of Medicine, the CCTS leverages expertise from several colleges at Ohio State, along with scientists and clinicians from OSU Medical Center and Nationwide Children's Hospital to improve the quality

of health care in the community. The grant award provides administrative support needed to develop improved methods for analyzing research data and managing clinical trials, allowing for greater community outreach, and creating partnerships. Faculty and staff from 16 colleges at OSU are involved in the project, creating a collaborative network focusing on science, education, research design and implementation. Training and developing the next generation of researchers is an integral part of the strategic focus. OSU is one of more than 30 institutions across the country receiving the NIH grant targeted to strengthening clinical and translational science. Led by the National Center for Research Resources, a component of the NIH, the CTSA program funds diverse and far-reaching approaches related to all aspects of research.

**The Infectious Disease Institute (IDI)**, was established in 2017 to build upon the successes of previous university programs and accelerate infectious disease research and education with a simpler, more integrated infrastructure. Directed by Michael Oglesbee, DVM, PhD, Dipl. ACVP brings together a vibrant and dynamic community that fosters a collaborative approach to address critical problems in infectious disease and the global environment. The impact and scope of the IDI's work is organized into six research areas, each of which focuses to eradicate infectious diseases in today's global space: Antimicrobial Resistance; Ecology, Epidemiology and Population Health; Host Defense and Microbial Biology; Microbial Communities; Prevention, Detection and Therapies; and Viruses and Emerging Pathogens.

**The Dorothy M. Davis Heart and Lung Research Institute (DHLRI)** was born from the multidisciplinary, problematic study of heart and lung disease at OSU in the late 1990s. In 2000, DHLRI opened its new home in one of the most advanced interdisciplinary facilities on the Ohio State campus. Today, the 100,000 sq. ft. institute offers research space for up to 50 PIs and their teams. Numerous core laboratories within the DHLRI offer state-of-the-art as well as innovative developing technologies to support all aspects of basic and clinical research. The clinical care provided nearby at the Ross Heart Hospital and other offices, clinics, and hospitals of the OSU Medical Center offers first-hand perspectives on how research affects the prevention, detection, and treatment of heart and lung disease. In order to maximize growth and excellence, the OSU DHLRI Institute concentrates research efforts in four areas that lead the institute into its next phase of scientific development under the direction of Peter Mohler, PhD: Regenerative Medicine; Inflammation, Fibrosis and Immune Function; Ischemia and Metabolism; and, Myocyte Biology. The four programmatic areas take into consideration many of the institute's existing strengths and promises to lay the groundwork for building bridges between basic science and clinical and translational investigation.

In addition to being active members of the university Centers/Institutes described above, The College of Veterinary Medicine has Signature Programs that foster collaboration in focused areas of interest. These programs invite participation of faculty, staff, residents and students from not only within the College but from across the University. These programs include the following:

**Comparative Oncology Signature Program** – The mission of the program is to improve the care and treatment of veterinary oncology patients by interdisciplinary collaborative efforts within the College of Veterinary Medicine, the Ohio State University biomedical community, and nationwide using enhanced diagnostic capabilities, state-of-the-art treatment, clinical trials, and translational medicine supported

by both basic and clinical research. Education of professional and graduate students, faculty, and the public are a vital component of this process. The overarching goal is a better understanding of the pathogenesis of cancer in all species, which will ultimately lead to optimized therapeutic modalities, improved quality of life for veterinary oncology patients and a stronger human-animal bond.

**Infectious Disease Signature Program** – The mission of the program is to benefit animal and public health by fostering infectious disease education and collaborative research through a platform of interactive collaborations and college-wide programmatic growth focused on veterinary infectious disease. There is broad faculty participation across multiple disciplines including virology, microbiology, immunology, clinical medicine, pathology/clinical pathology, and epidemiology to address the three key areas of population health, host response, and structure and function. Organized efforts promote the training of professional and graduate students, as well as further the education of faculty and staff.

The **Animal Diagnostic Disease Laboratories of the Ohio Department of Agriculture** is located 20 minutes from the department, supporting rotations of first year pathology residents on the autopsy floor and via interpretation of "mail-in" cases. These rotations expose the residents to pathology of production animals as well as diagnostic support services that include toxicology and microbiology.

The University is adjacent to the headquarters for **Battelle Memorial Institute**, one the largest non-profit research organizations in the world. Battelle staffs toxicologists and infectious disease investigators that have served as both instructors and consultants for training activities within the Department of Veterinary Biosciences.

The Department of Veterinary Biosciences and the CVM Veterinary & Comparative Medicine Graduate Program are active participants in two interdisciplinary graduate programs:

**Biomedical Sciences Graduate Program (BSGP)** is a unique graduate program within the OSU College of Medicine and Public Health that has an extremely strong Graduate Faculty composed of over 170 members from 19 departments. These faculty members bring extraordinary research and teaching expertise and outstanding research resources to the program.

The Graduate Program in **Molecular, Cellular and Developmental Biology (MCDB)** is an interdisciplinary unit involving the collaborative efforts of over 140 faculty members from twenty-five departments in six colleges: Biological Sciences, Food, Agriculture and Environmental Sciences, Medicine and Public Health, Pharmacy, Mathematical and Physical Sciences, and Veterinary Medicine. MCDB offers a course of study leading to the doctoral degree. Research training is diverse and areas of study include: Cell Biology, Gene Expression, DNA Replication, Developmental Biology, Molecular Medicine, Virology, Cancer Biology/Genetics, Plant Molecular Biology, Molecular Neurobiology, and RNA Processing.

There are innumerable Core Facilities and Shared Resources, including but not limited to those listed below, for use by OSU investigators and graduate students. Clinical research faculty, basic scientists and students all benefit from the shared cost of these resources, and the research environment at OSU benefits from the economies of scale that enable timely acquisition of new instrumentation and technologies.

**Analytical Cytometry and Cell Sorting** – directed by Jeffrey Chalmers, PhD – provides instrumentation, technical operation and support for identification, characterization and separation of cell populations according to the expression of selective cellular markers.

**Nanosystems** – The Nanosystems Lab – directed by Denis Pelekhov, PhD – provides academic and industrial users with access to advanced material characterization and fabrication tools for research and development applications. Research capabilities available include focused ion beam/scanning electron microscopy, e-beam lithography, nanomanipulation, EDS X-ray microanalysis, X-ray diffractometry, SQUID magnetometry, atomic force/magnetic force microscopy, low temperature magnetotransport measurements and Langmuir-Blodgett trough monolayer deposition.

**Behavioral Phenotyping** – This facility in the Biomedical Research Tower vivarium is led by Randy Nelson, PhD and Matthew During, MD, PhD. It offers specialized equipment and collaborative expertise for monitoring an array of behavioral responses. A partial list of behaviors and monitoring equipment includes a multifunction video system for digital monitoring of operant and preference conditioning. Monitoring of diurnal patterns, locomotion, feeding, social interactions, learning and memory, anxiety and depression is also available. Many of these tasks can be accomplished through a newly purchased Clever Systems analysis suite. Standard phenotyping includes: health screening, sensorimotor assessment, learning and memory, balance and coordination, anxiety and stress responses, motivated behavioral assessments, aggressive behaviors, mating behaviors, parental behaviors, food and water intake, social interactions, acoustic startle and prepulse inhibition tests. This Core will provide technical expertise and consultation. Behavioral data is collected in modern facilities under controlled conditions.

**Biomedical Informatics** – Led by Kevin Coombes, PhD, the Biomedical Informatics Core Laboratory, organized into two complementary arms - Computational Biology Services (CBS) and Data Management Services (DMS) - analyzes high-throughput, high dimensional biological data and other biomedical data and information using state-of-the-art informatics tools and high-quality informatics analysis.

**Biorepository and Biospecimen (BBR)** – Led by Heather Hampel, MS, CGC, this resource procures and provides procured tissue and fluid biospecimens to investigators for IRB-approved and grant-funded projects. Biospecimen Services also includes a universal lifetime consenting and biobanking protocol, Total Cancer Care® (TCC) which allows for the collection of blood in conjunction with clinically indicated draws and remnant tissue from surgical procedures from patients 18 years of age and older, with and without cancer. Participation also includes consent to use of their medical and genomic information. TCC is

the single protocol used by the Oncology Research Information Exchange Network (ORIEN), which includes 17 cancer centers and counting.

**Biostatistics** – Led by Soledad Fernandez, PhD, this resource helps researchers identify collaborators for grant preparation, create and maintain databases, analyze data, develop methodologies and publish results. It is available to assist trainees in all aspects of grant proposal development, experimental design, sample size determination, data management, statistical analysis, development and application of statistical methods, and manuscript preparation. This is but a small component of a larger university investment in Translational Data Analytics (<http://discovery.osu.edu/tda/>).

**BSL3 Facilities** – OSU is recognized as an emerging leader in infectious diseases and biodefense research. A key component of this research program is the availability of state-of-the-art Biosafety Level 3 (BSL3) biocontainment facilities. OSU operates three BSL3 facilities with approximately 8600 sq. ft. of laboratory space. To facilitate research, BSL3 users have access to a number of shared core equipment including incubators, biosafety cabinets, fridges and freezers, centrifuges, flow cytometer, and cryostat.

**Campus Microscopy and Imaging Facility (CMIF)** – The Campus Microscopy and Imaging Facility (CMIF), under director Paul Stodley, PhD, provides an accessible centrally-organized resource with technical support for light and electron microscopy. Highly qualified faculty and staff provide training and advice for sample preparation, sample processing, basic microscopy, and advanced training for imaging live samples.

**Clinical Trials Office (CTO)** – The CTO, under the leadership of William Carson, MD, facilitates development and implementation of all Ohio State University CCC – James Cancer Hospital and Solove Research Institute clinical trials, including regulatory processing, subject recruitment, data collection and protocol-management services.

**Clinical Treatment Unit and Clinical Trials Processing (CTU/CTPL)** – This facility, led by Larry Schaaf, PhD, enables investigators at the CCC-James to conduct successful phase I and phase II clinical translational research in a methodologically sound, expedient and cost effective manner. CTU specializes in treating early clinical trial patients who require intense monitoring or complex correlative sample collection and processing. CTPLS enhances research quality by providing dedicated staff for high-volume procurement, processing, storage, delivery and shipment of research specimens critical to the correlative studies component of CCC-James clinical trials.

**Comparative Pathology & Mouse Phenotyping Shared Resource (CPMPSR)** – The heavy utilization of genetically modified animals within the Health Sciences Center and the demands of the University Laboratory Animal Resources (ULAR) represent a highly utilized training opportunity for the pathology resident. Our department is home to the Comparative Pathology & Mouse Phenotyping Shared Resource (CPMPSR) under the direction of Drs. Krista La Perle (Director) and Sue Knoblauch (Associate Director). The CPMPSR provides pathology support to investigators utilizing animal models to study disease. Services, which emphasize phenotypic characterization of newly produced lines of genetically engineered

mice and preclinical efficacy and toxicity studies, include comprehensive macroscopic and microscopic examinations of various laboratory animal species. Additional services include hematology, clinical chemistry, radiography, routine frozen and paraffin slide preparation, transmission electron microscopic grid and tissue microarray preparation, and special histochemical, immunohistochemical and immunofluorescent staining. Extensive capabilities are also available for microscopic slide digitization (brightfield, fluorescence and z-stacking) and quantitative image analysis (Leica's Toolbox with TMA Lab and Visiopharm). In addition, the CPMPSR provides a referral service to experienced scientists, providing expertise in animal model development, experimental design, optimal sample collection and data interpretation. The three veterinary pathologists (La Perle, Knoblauch, Corps) dedicated to the CPMPSR support rotations by both anatomic and clinical pathology residents, laboratory animal residents and veterinary students; coordinates monthly laboratory animal pathology rounds.

**Genetically Engineered Mouse Modeling (GEMM)** – The GEMM Shared Resource, under the direction of Vincenzo Coppola, MD, assist investigators in the generation of classical transgenic lines by pronuclear injection of DNA and targeted lines (knock-out, knock-in, conditional) by embryonic stem cell technology and by CRISPR/Cas9 technology. CRISPR services include designing of the targeting strategy and screening of F1 germ line-transmitted mutant mice. Crisprized human and mouse cell lines have been produced. It also offers sperm or embryo cryopreservation, rederivation, and in vitro fertilization services.

**Genomics (GSR)** – The Genomics Shared Resource, provides both nucleic acid and microarray services under the direction of Richard K. Wilson, PhD and Amanda Toland, PhD, FACMG. It offers instrumentation and expertise for DNA and RNA analysis using sequencing, genotyping, real-time PCR, Affymetrix GeneChips, nCounter Analysis, next-generation sequencing library generation, next-generation sequencing and QC for DNA/RNA/Proteins.

**Gnotobiotics** – facilities are available to support the use of germ free and gnotobiotic mice as well as larger species including cats, dogs and pigs.

**Leukemia Tissue Bank** – This resource, led by David Lucas, PhD, provides central collection, processing, and repository for tissue samples and derivatives (plasma, serum, DNA, RNA and protein) collected from leukemia patients treated on Ohio State University protocols for use in pre-clinical research.

**Medicinal Chemistry** – Under the direction of Chad Bennett, PhD, this resource integrates the expertise of multiple disciplines, including synthetic and process chemistry, instrumental analysis and molecular pharmacology to provide medicinal chemistry services, including chemistry consultations, sample purity analyses and preparations, and custom syntheses for the identification of new therapeutic targets and/or biomarkers of drug activity.

**Molecular and Cellular Imaging Center** – directed by Tea Meulia, PhD and located at the Ohio Agricultural Research and Development Center on OSU's Wooster campus, it is fully equipped to conduct biological research at the subcellular and ultrastructural level through

light microscopes that facilitate laser capture microdissection, confocal microscopes, a transmission electron microscope, and two scanning electron microscopes.

**Nutrient and Phytochemical Analytix** – Ken Riedl, PhD is acting director of this resource which brings world class expertise and cutting edge LCMS instrumentation to analytical exploration of foods and biologics. This includes targeted and untargeted metabolomics for biomarker identification and metabolite discovery. Metabolomics is an experimental capability providing unrivaled depth of metabolite coverage to enhance scientific rigor of investigations and competitiveness of grants. Staff have particular experience in metabolomics as applied to a ‘Crops to Clinic’ approach with dietary interventions for cancer prevention, and support the OSU Discovery Themes in Foods for Health.

**Pharmacanalytical** – This resource is a decentralized facility in the College of Pharmacy led by Mitch Phelps, PhD which supports pre-clinical and clinical drug development at Ohio State by providing high quality and cost-effective bioanalytical method development, quantitative sample analysis, and pharmacokinetic/pharmacodynamic experimental design, data analysis and modeling. Expertise among personnel includes quantitative pharmacology; bioanalytical methodology, design and conduct of pharmacokinetic/pharmacodynamic studies in animal disease models and in humans enrolled in clinical trials; data analysis and modeling of PK/PD data to inform drug development decisions. Personnel are available for consultation on clinical or pre-clinical PK/PD experimental design and analysis.

**Pharmacogenomics** – Led by Audrey Papp, the Core Laboratory of Ohio State’s Program in Pharmacogenomics supports molecular genetics and genomics technologies, biomarker development, and clinical translation, to enhance personalized therapy of complex disorders. The Center for Pharmacogenomics also serves as home to XGEN (Expression Genetics in Drug Therapy), a member group of the NIH Pharmacogenomics Research Network (PGRN), dedicated to discovery of clinical biomarkers to guide personalized medicine.

**Proteomics (PSR)** – The Proteomics Shared Resource, directed by Micheal Freitas, PhD and located in the Biomedical Research Tower, provides access to advanced mass spectrometry instrumentation and analysis for protein identification, characterization, and quantification. Using a variety of analytical platforms, researchers are able to discover novel differentially expressed proteins in serum, urine, BAL fluid, saliva, frozen tissues, formalin-fixed tissues and cell lysates. Technical expertise and state-of-the-art instrumentation is used to identify proteins, protein modifications, protein interactions and protein biomarkers as well as protein quantitation studies from solution, 1D and 2D gels using electrophoresis and imaging equipment, robotic sample handlers and (tandem) mass spectrometers. The PSR is part of the [Campus Chemical Instrument Center](#) managed by the OSU Office of Research.

**Small Animal Imaging** – directed by Kimerly Powell, PhD, this resource provides high-resolution imaging equipment, personnel trained in the operation of each imaging modality and small-animal-handling procedures, and analytical software support for quantitative image analysis. The facility houses magnetic resonance imaging (MRI), high-frequency ultrasound (US), bioluminescence and fluorescence optical Imaging system (BLI/FL), echoMRI for body composition analysis, and computed tomography and X-ray irradiation platform

(SARRP). All imaging instrumentation comes fully equipped with biological (ECG, respiration, temperature) monitoring equipment and isoflurane anesthesia systems. The instrumentation can be used for *in vivo* animal imaging or *ex vivo* specimen investigations.

**Solid Tumor Translational Science** – Pravin Mishra, PhD directs this shared resource which works closely with clinical and translational scientists to develop a customizable portfolio of biomarker assays in order to provide innovative, correlative science studies associated with early-phase solid tumor oncology clinical trials. This resource works closely with clinical investigators in the design and management of studies and provides guidance related to assay development and analysis, serves as a central repository for specimens collected from patients on trials and is responsible for processing the tissue for any number of downstream analyses. In addition to developing novel assays, this shared resource partners with other shared resources to utilize available technologies such as next-generation sequencing, RNA expression analysis and proteomics. In these situations, the Solid Tumor Translational Science Shared Resource is responsible for obtaining and preparing the patient samples for downstream analyses, and then collecting and organizing the data. Personnel also help identify and develop partnerships among investigators and pharmaceutical companies to gain access to new drugs and compounds and to provide corresponding correlative testing and analyses for cancer studies.

**Target Validation (TVSR)** – Reena Shakya, PhD directs the TVSR which assists investigators in generating reliable proof-of-concept preclinical animal model data for grant applications, publications, and IND applications for the FDA through expertise in establishing breeding programs for GEMM (genetically engineered mouse model) animals and immune-compromised mouse strains, developing xenograft/allograft mouse models of cancer, therapeutic compound administration, and subsequent monitoring of the animals.

**Veterinary Clinical Research Support (VCRSSR)** – The (VCRSSR), housed in the College of Veterinary Medicine and led by Cheryl London, DVM, PhD designs and conducts clinical trials in companion animals with spontaneous diseases to evaluate novel diagnostics and therapeutics and collects biospecimens, such as tissue biopsies, serum, plasma and urine, in support of comparative cancer research. The overriding goal of this resource is to advance the diagnosis and treatment of disease in veterinary patients while enhancing the health of humans through comparative and translational studies.

**Wright Center for Innovation in Biomedical Imaging** – Directed by Michael V. Knopp, MD, PhD, the 4.7T/40cm MRI facility was created as part of the Ohio Cellular and Molecular Imaging Consortium (OCMIC) with the goal to advance state-of-the-art technology for non-rodent animal imaging at the molecular, cellular and system level, to serve as a resource for medical research, biotechnology advances and pharmaceutical development, and for probing *in vivo* gene function, disease processes and therapeutic applications including drug delivery and trials. The goal of the consortium is to facilitate inter-institutional collaboration between academic institutions in Ohio and technology transfer to Industry.

**Viral Vector** – An affiliated core at The Cincinnati Children’s Hospital Medical Center, which produces research-grade lentiviral, gamma retroviral and adeno-associated viral vectors, generates stable producer lines, and offers non-GMP quality control testing, including vector titer by functional assay FACS or PCR, endotoxin, mycoplasma, and USP sterility testing. This core is led by William Swaney, MS.

#### **E) Pathology Case Load and Species Distribution:**

##### **Clinical Laboratories Case Load (7/1/17-6/30/18):**

Hematology clinical cases	12,279
Cytology clinical cases	3,161
Biochemistry clinical cases	20,418
Total	35,858

##### **Anatomic Pathology Case Load and Species Distribution (2018):**

**Autopsies:** 989 total cases (mean=19/wk) submitted from the OSU Veterinary Medical Center, referring veterinarians, the Columbus Zoo and the Capital Area Humane Society.

46%	dog
23%	cat
14%	equine
7%	bovine
4%	zoo/wildlife/lab
3%	ovine/caprine
2%	camelid
1%	porcine

**Surgical Biopsies:** 1314 total cases (mean=25/wk) submitted from the OSU Veterinary Medicine Center and the Columbus Zoo.

75%	dog
9%	cat
8%	equine
6%	zoo/wildlife/lab
2%	camelids/ruminants/porcine

**Columbus Zoo:** Species submitted to the department for post mortem examination have included fish, reptiles, amphibians, rodents, birds, primates, zebras, antelopes, wolves, crocodiles, moose, cheetahs, bears, giraffes, and rhinoceros. Elephants are posted on zoo premises by response teams from the department.

Cases submitted to the **Animal Diagnostic Disease Laboratories (ADDL)**, Ohio Department of Agriculture, can be subdivided as follows:

Necropsies: 1-10/week\*

Mail-in cases: 3-5/week

60% Production animals including cattle (beef and dairy), small ruminants (sheep and goats), pigs, chickens.

20% Small animals (dogs and cats)

10% Equine

5% Camelids

5% Wildlife (birds, deer, raccoons, etc.)

\* These numbers reflect the one day per week that each resident spends at the ADDL.

**F) Pathology and Research Faculty:**

The table that follows outlines the roles of **faculty whose primary appointments are in VBS and who are instrumental in supporting pathology residency training and/or research.** Space precludes inclusion of all CVM-appointed and joint-appointed graduate faculty associated with the CVM Comparative & Veterinary Medicine Graduate Program.

Name	Title(s)	Degrees and Certifications	% Effort Devoted to Pathology/ Research	Involvement in Pathology/Research Training
Prosper Boyaka	Professor	PhD	10/85	Principal investigator (mucosal immunity/allergy); graduate course instruction; flow cytometry and immunophenotyping; graduate committees
Mary Jo Burkhard	Associate Professor; Associate Dean for Faculty & Staff Affairs, Inclusive Diversity & Planning	DVM, PhD, DACVP (Clinical Pathology)	10/5	Clinical pathology didactic instruction; graduate committees

Rachel Cianciolo	Associate Professor; Co-Director, International Veterinary Renal Pathology Initiative	DVM, PhD, DACVP (Anatomic Pathology)	75/20	Didactic and seminar instruction in renal pathology; autopsy and surgical pathology; International Veterinary Renal Pathology Initiative; graduate committees
Kara Corps	Assistant Professor	DVM, PhD, DACVP (Anatomic Pathology)	75/20	Didactic and seminar instruction in musculoskeletal and laboratory animal pathology; Team Leader, weekly histopathology seminar; research pathology support; collaborative research; graduate committees
Estelle Cormet-Boyaka	Associate Professor; <b>Member, CVM Council for Graduate Studies</b>	MS, PhD	0/80	Principal investigator (epithelial cell homeostasis in response to drugs, pollutants, and viral or bacterial pathogens); graduate committees
Alexander Davies	Assistant Professor	DVM, PhD	0/80	Principal investigator (influence of signaling via soluble factors and exosomes on phenotypic behavior of cancer cells and microenvironment); graduate committees
Ian Davis	Professor	DVM, PhD	5/75	Didactic and seminar instruction in laboratory animal medicine and statistics; principal investigator (pathogenesis of acute viral diseases of the lung); graduate committees

Samantha Evans	Assistant Professor	DVM, PhD	75/20	Clinical Pathology Service; didactic and seminar instruction in clinical pathology; flow cytometry; graduate committees
Patrick Green	Professor; <b>Associate Dean for Research and Graduate Studies, College of Veterinary Medicine;</b> Director, Center for Retrovirus Research	PhD	0/50	Principal investigator (regulation of HTLV gene expression and cellular transformation); graduate course instruction; graduate committees
Jessica Hokamp	Assistant Professor; <b>Clinical Pathology Training Coordinator;</b> <b>Combined Pathology Residency/Graduate Program Co-Director</b>	DVM, PhD, DACVP (Clinical Pathology)	75/20	Clinical Pathology Service; didactic and seminar instruction in clinical pathology; International Veterinary Renal Pathology Initiative; graduate committees
Ryan Jennings	Assistant Professor	DVM, PhD, DACVP (Anatomic Pathology)	75/20	Didactic and seminar instruction in respiratory and dermatologic pathology; autopsy and surgical pathology; graduate committees
Sanggu Kim	Assistant Professor	PhD	0/85	Principal investigator (hematopoietic stem cell and T-cell gene therapy; systems biology of virus-host interactions; lentiviral vector-mediated cell-tracking); graduate committees

Sue Knoblaugh	Associate Professor; Associate Director, Comparative Pathology & Mouse Phenotyping Shared Resource	DVM, DACVP (Anatomic Pathology)	20/65	Didactic and seminar instruction in laboratory animal pathology and general pathology; Team Leader for Biology of Disease in veterinary core curriculum; research pathology support; collaborative research; graduate committees
Krista La Perle	Professor; <b>Anatomic Pathology Training Coordinator; Combined Pathology Residency/Graduate Program Co- Director;</b> Director, Comparative Pathology & Mouse Phenotyping Shared Resource; <b>Chair, CVM Council for Graduate Studies</b>	DVM, PhD, DACVP (Anatomic Pathology)	20/55	Didactic and seminar instruction in laboratory animal pathology (diseases of mice, rats, non-human primates and zebrafish), hepatobiliary and gastrointestinal systems; Team Leader, Advanced Systemic Pathology; research pathology support; collaborative research; graduate committees
Jianrong Li	Professor	DVM, PhD	0/80	Principal investigator (entry, replication, gene expression and pathogenesis of norovirus and human metapneumovirus; pathogenesis and vaccinology of porcine enteric coronaviruses; graduate committees

Shan-Lu Liu	Professor	PhD	0/80	Principal investigator (host restriction to viral infection/viral countermeasures; viral cell-to-cell transmission; innate immunity/sensing to viral infection; mechanisms of viral membrane fusion/entry; models include HIV, Ebola, Influenza A, Zika Virus, Hepatitis C Virus, Sheep retroviruses); graduate committees
Stefan Niewiesk	Professor; Chair, Department of Veterinary Biosciences	DVM, PhD, DECLAM	5/65	Didactic and seminar instruction in laboratory animal medicine; principal investigator (immune modulation by measles virus); graduate course instruction; graduate committees
Michael Oglesbee	Professor; Faculty Lead, University Discovery Theme in Infectious Disease; Director, Infectious Disease Institute; <b>Member, CVM Council for Graduate Studies</b>	DVM, PhD, DACVP (Anatomic Pathology)	10/15	Didactic and seminar instruction in neuropathology; autopsy and surgical pathology; principal investigator (cellular stress response in viral infections); graduate course instruction; graduate committees
Christopher Premanandan	Associate Professor; Service Head, Veterinary Anatomic Pathology	DVM, PhD, DACVP (Anatomic Pathology), DACT	75/20	Didactic and seminar instruction in cardiac, reproductive, ophthalmic and large animal pathology; autopsy and surgical pathology; cytology rounds; graduate committees

Yasuko Rikihisa	Professor	MS, PhD	0/80	Principal investigator (host cell receptors and signal transduction of Ehrlichiae); graduate committees
Heather Shive	Assistant Professor	DVM, PhD, DACVP (Anatomic Pathology)	10/80	Principal investigator (identification of conserved genetic, genomic and microenvironmental factors essential for initiation and promotion using zebrafish model for BRCA2-associated cancer); graduate committees; autopsy and surgical pathology; seminar instruction in pathology
Paul Stromberg	Professor Emeritus	DVM, PhD, DACVP (Anatomic Pathology)	20/0	Seminar instruction in histopathology and gross pathology instruction
Steven Weisbrode	Professor Emeritus	VMD, PhD, DACVP (Anatomic Pathology)	20/0	Weekly histopathology and monthly specialty pathology seminar instruction
Maxey Wellman	Professor; Service Head, Veterinary Clinical Pathology	DVM, PhD, DACVP (Clinical Pathology)	90/5	Clinical Pathology Service; Didactic and seminar instruction in clinical pathology; graduate committees
Li Wu	Professor	PhD	0/80	Principal investigator (molecular mechanisms of HIV replication/retroviral pathogenesis, molecular mechanisms of cutaneous T-cell lymphoma); graduate committees

**G) Current Pathology Residents/Graduate Students:**

Name of Resident	Type of Residency/ Graduate Program	Graduate Advisor	ACVP Exam		Program Start- Expected Completion Dates*
			Year(s) Attempted	Year Passed	
Justin Breitbach	Clinical/ PhD	Fenger	Phase I-2016 Phase II-2018	Phase I-2016 Phase II-2018	2015-2020
Mary Evelyn White	Clinical	N/A	Phase I-2019 Phase II-2019	Phase I-2019	2016-2019
Camille McAloney	Clinical/ PhD	Roberts	Phase I-2019	Phase I-2019	2017-2022
Mackenzie Long	Clinical/ PhD	Baiocchi/ Alinari	-----	-----	2018-2023
Susan Smith	Clinical/ PhD	TBD	-----	-----	2019-2024
<b>Summary: 5 Clinical Pathology Trainees 4/5 (80%) Clinical Pathology-PhD Trainees</b>					
Margaret (Shoemaker) Martinez	Anatomic/ PhD	Niewiesk	Phase I-2017 Phase II-2019	Phase I-2017	2014-2019
Joshua Lorbach	Anatomic/ PhD	Bowman	Phase I-2016	Phase I-2016	2014-2019
Timothy Helms	Anatomic/ PhD	Clinton/Coss	Phase I-2018	Phase I-2018	2015-2020
Tiffany Jenkins	Anatomic/ PhD	Peeples	Phase I-2018 Phase II-2019	Phase I-2018	2015-2020
Michael Martinez	Anatomic/ PhD	Green	Phase I-2018	Phase I-2018	2015-2020
Greg Ballash	Anatomic/ PhD	Wittum	-----	-----	2016-2021
Kelsey Brakel	Anatomic/ PhD	Niewiesk	Phase I-2019	Phase I-2019	2016-2021
Mallory DiVincenzo	Anatomic/ PhD	Carson	Phase I-2019	Phase I-2019	2016-2021
James Cronin	Anatomic/ PhD	Byrd/ Lapalombella	-----	-----	2017-2022
Ching Yang	Anatomic/ PhD	Montgomery	-----	-----	2017-2022
Jennifer Geisler	Anatomic/ PhD	G. Sizemore/ Chandler	-----	-----	2018-2023
Sarah Linn	Anatomic/ PhD	Sharma	-----	-----	2018-2023
Allison Mustonen	Anatomic/ PhD	Byrd/ Hertlein	-----	-----	2018-2023

Melissa Leonard	Anatomic/PhD	TBD	----	----	2019-2024
Betsey Pray	Anatomic/PhD	TBD	----	----	2019-2024
<b>Summary: 15 Anatomic Pathology Trainees</b>					
<b>15/15 (100%) Anatomic Pathology-PhD Trainees</b>					

TBD: To be determined, 1<sup>st</sup> year in program.

#### H) Past Residents (since 2001):

Name of Resident	Type of Residency/Graduate Program and Date Completed	Graduate Advisor	ACVP Exam		Current Position
			Year(s) Tested	Year(s) Passed	
James Stanley	Anatomic/MS 2001	Lairmore	2000	2000	Alizee Pathology, LLC
Rani Sellers	Anatomic/PhD 2001	Rosol	2000	2000	Pfizer
Bruce LeRoy	Clinical/PhD 2002	Rosol	2002	2002	AbbVie
Julie Hutt	Anatomic/PhD 2002	DeWille	2001	2001	Histo-Scientific Research Laboratories
Krista La Perle	Anatomic/PhD 2002	Capen/Jhiang	2001	2001	Professor, The Ohio State University
Alan DeBruin	Anatomic 2001	N/A	2001, 2002	2002	Professor, State University of Utrecht, The Netherlands
Laura Rush	Anatomic/PhD 2003	Plass/Caligiuri	2002, 2003	2003	Ohio Health, Clinical and Translational Research Unit Executive Director
Richard Peterson	Anatomic/PhD 2003	Eaton	2003	2003	AbbVie
Wayne Buck	Anatomic/PhD 2004	Podell/Mathes	2001	2001	AbbVie
Deborah Davis	Clinical 2005	N/A	2005, 2006	2006	Clinical Pathologist, IDEXX Laboratories
Hajime Hilaragi	Anatomic/PhD 2005	Lairmore	2005	2005	Lyell Immunopharma

Lee Silverman	Anatomic/PhD 2005	Lairmore	2005	2005	Agios
Sarah Tannehill-Gregg	Anatomic/PhD 2005	Rosol	2005, 2006	2006	Director, Toxicology Takeda Pharmaceuticals International
Colleen Almgren	Anatomic/PhD 2005	Brooks	2005, 2006	-----	Pet Poison Helpline
Kim Newkirk	Anatomic/PhD 2007	Kusewitt	2007	2007	Professor, University of Tennessee
Stephanie Corn	Clinical 2005	N/A	2005	2005	Clinical Pathologist, IDEXX Laboratories
Deanna Schaefer	Clinical/MS 2006	Rush	2006	2006	Assistant Professor, University of Tennessee
Stephan Schmidbauer	Anatomic 2006	N/A	-----	-----	Boehringer- Ingelheim Pharma GmbH & Co. KG
Katie Knostman	Anatomic/PhD 2007	Capen/ Jhiang	2007	2007	Histo-Scientific Research Laboratories
Prasad Nadella	Anatomic/PhD 2007	Rosol	2008	2008	AstraZeneca Pharmaceuticals
Tracey Papenfuss	Anatomic/PhD 2007	Whitacker	2007	2007	MPI Research/Charles River
Christopher Premanandan	Anatomic/PhD 2007	Lairmore	2007	2007	Associate Professor, The Ohio State University
Matthew Buccellato	Anatomic/PhD 2008	Oglesbee	2008	2008	Histo-Scientific Research Laboratories
Shane Besier	Anatomic 2008	N/A	2008	2008	Staff Pathologist, Animal Health Laboratories, Dept. of Agriculture and Food, Govt. of Western Australia
Denise Schwahn	Anatomic 2008	N/A	2008	2008	Zoetis

Gillian Beamer	Anatomic/PhD 2009	Schlesinger	2008	2008	Assistant Professor, Tufts University
Brenda Yamamoto	Clinical/PhD 2008	Green	2008, 2009	2009	Enanta Pharmaceuticals
Aaron Sargeant	Anatomic/PhD 2009	Chen	2008	2008	Charles River
Bevin Zimmerman	Anatomic/PhD 2009	Lairmore	2008, 2009	2009	Charles River
Tzu-Yin Lin	Clinical/PhD 2009	London	2009, 2010	2010	Assistant Researcher, University of California Davis Cancer Center
Cecilia Machado-Parrula	Clinical/PhD 2008	Niewiesk	2008, 2009	2009	Vertex Pharmaceuticals
Mary Carsillo	Anatomic/PhD 2009	Niewiesk	2008, 2009	2009	Director, Global Pathology Lead, Drug Safety Research and Evaluation, Takeda Pharmaceuticals International
Erin Brannick	Anatomic/MS 2010	Stromberg	2009, 2010	2010	University of Delaware
Stacey Fossey	Anatomic/PhD 2010	London	2010	2010	AbbVie
Alex Hamberg	Anatomic/PhD 2010	Krakowka	2010, 2011, 2012, 2013	-----	Pennsylvania Veterinary Laboratory, Harrisburg, PA
Chelsea Martin	Anatomic/PhD 2010	Rosol	2010	2010	Assistant Professor, Atlantic Veterinary College, University of Prince Edward Island
Laurie Millward	Clinical/MS 2010	Lairmore	2012, 2013, 2014, 2015	2015	Assistant Professor, Ohio State University
Dirk Schaudien	Anatomic 2010	N/A	2010	2010	Fraunhofer Institute for Toxicology and Experimental Medicine

Tracy Carlson	Anatomic/PhD 2011	Schlesinger	2010	2010	MPI Research/Charles River
Jennifer McCleese	Clinical/PhD 2011	London	2010, 2011	2011	Interviewing
Rebecca Urbiztondo	Clinical/MS 2011	Lairmore	2011, 2012	2012	Great Lakes Veterinary Specialists; PetLabs, Inc.
Nadine (Bowden) Ramos	Anatomic/PhD 2011	Lairmore	2012, 2014, 2015	-----	Staff Fellow, US Food and Drug Administration
Kendra Wolk	Anatomic/MS 2012	Davis	-----	-----	Kingdom Animal Hospital (Owner)
Jennifer Mathews	Clinical/PhD 2012	Gebreyes	2011, 2012	2012	Veterinary Technology Program Director, Southwest Georgia Technical College
Lisa Lanigan	Anatomic/PhD 2012	Rosol	2012, 2013, 2014	2014	Charles River
Robyn Haines	Anatomic/PhD 2012	Lairmore	2012, 2013	2013	Kord Disease Diagnostic Laboratory, Nashville, TN
Emily (Piecarka) Walters	Clinical 2012	N/A	2012, 2013	2013	Antech, Irvine, CA
Kelly Santangelo	Clinical/PhD 2012	Bertone	2012, 2013, 2014	2014	Assistant Professor, Colorado State University
Jessica Grieves	Anatomic/PhD 2012	Oglesbee/ Durbin	2012	2012	Takeda Pharmaceuticals International
Lisa Berman-Booty	Anatomic/PhD 2013	Chen	2010	2010	Principal Pathologist, Bristol- Myers Squibb
Beth (Chaffee) Dray	Anatomic/PhD 2013	Allen	2010	2010	Charles River
Famke Aeffner	Anatomic/PhD 2013	Davis	2012, 2013, 2014	2014	Amgen

Lyn Wancket	Anatomic/PhD 2013	Liu	2011, 2012, 2013	2013	Charles River
Kristin (Lewis) Wilson	Anatomic/PhD 2014	Lucchesi	2014, 2015	2015	Amgen
Jessica Simmons	Anatomic/PhD 2014	Rosol	2014, 2015	2015	Seattle Genetics, Inc.
Lauren (Mattei) Himmel	Anatomic/PhD 2016	Chen	Phase I- 2016 Phase II- 2016	Phase I- 2016 Phase II- 2016	Assistant Professor, Vanderbilt University Medical Center
Sarah Chaney	Anatomic/PhD 2016	Wozniak	2015	2015	Bronx Zoo, Zoo Residency
Elizabeth Clark-Melamed	Anatomic/PhD 2017	Breuer	Phase I- 2015 Phase II- 2016	Phase I- 2015 Phase II- 2016	Boehringer Ingelheim
Sally Henderson	Clinical/PhD 2017	Chen	Phase I- 2016 Phase II- 2017	Phase I- 2016 Phase II- 2017	Battelle
Nicole Kohart	Clinical/PhD 2017	Rosol	Phase I- 2018	-----	Banfield Pet Hospital, Virginia Beach, VA
Rebecca Kohnken	Anatomic/PhD 2017	Mishra/ Caligiuri	Phase I- 2016 Phase II- 2017	Phase I- 2016 Phase II- 2017	AbbVie
Christopher Koivisto	Anatomic/PhD 2018	Leone	Phase I- 2018	Phase I- 2018	Hollings Cancer Center, Medical University of South Carolina
Bonnie Harrington	Anatomic/PhD 2018	Byrd	Phase I- 2016 Phase II- 2017	Phase I- 2016 Phase II- 2017	Assistant Professor, Michigan State University
Nina Zitzer	Clinical/PhD	Garzon	Phase I- 2016 Phase II- 2018	Phase I- 2016 Phase II- 2018	Covance Laboratories, Inc.

N/A: Not applicable, residency training only.

### Summary:

- 64 individuals have graduated from our program since 2001
- 60/64 (94%) individuals have sat for the ACVP [Phase II] Board Certification Examination (4 individuals [3 anatomic and 1 clinical] have never taken the exam):
  - Current pass rate for clinical pathology: 15/15 = 100%

- Current pass rate for anatomic pathology:  $42/45 = 93\%$
- 50/64 (78%) individuals have earned PhDs since 2001
- 5/64 (8%) individuals have earned MS degrees since 2001
- 50/55 (91%) graduate students have taken and successfully completed the ACVP Board Certification Examination since 2001, 38 in anatomic pathology and 12 in clinical pathology
- Graduates are currently employed in:
  - Pharma/Biotech: 35/64 (55%)
  - Academia: 15/64 (23%)
  - Diagnostic Lab/Government: 7/64 (11%)
  - Other: 7/64 (11%)