The authors wish to dedicate this book to their mentors, the pioneers in veterinary clinical pathology. In particular, the book is dedicated to Drs. Maxine Benjamin, Oscar Schalm, and J.J. Kaneko for their respective first-generation discovery and textbooks addressing veterinary clinical pathology, hematology, and clinical chemistry and for their inspiration to the many subsequent careers in veterinary clinical pathology.

Dr. Mary Anna Thrall wishes to thank and remember Dr. Maxine Benjamin for her generosity, patience, and friendship. The authors acknowledge and remember Dr. E. Duane Lassen for his important contributions to the first edition of this textbook. He has since lost a hard-fought battle with cancer. He was an outstanding teacher, excellent clinical pathologist, and dear friend across much of the veterinary clinical pathology community.
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Extra PowerPoint presentations available online at www.wiley.com/go/thrall.
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On behalf of the contributing authors and Wiley-Blackwell we are pleased to introduce the Second Edition of Veterinary Hematology and Clinical Chemistry. Our goal is to provide an image-rich, readable resource addressing routine laboratory diagnostics in veterinary practice. The theme of the presentation is applied clinical pathology for veterinary students and veterinary health professional teams in the practice setting. We aimed to maintain our intended target audience and original organizational structure.

**Audience**

A continuing trend in frontline veterinary medicine is the movement of laboratory diagnostics into the veterinary facility. Evolving technological advancements in point-of-care diagnostic capability drives this trend, which increases the need for education in veterinary clinical pathology. Although this book was written primarily for veterinary students and practitioners, it has applications for a broader audience, serving as a useful adjunct for the educational and reference needs of a variety of other users. The following audiences may benefit from this resource:

- students in professional veterinary medical education programs;
- health professional teams in veterinary care facilities;
- clinical pathologists and clinical pathologists in training;
- product development groups utilizing veterinary clinical pathology.

**Organization**

Veterinary Hematology and Clinical Chemistry is organized into six sections, arranged as follows:

- I: presents principles of laboratory technology and test procedures used in veterinary laboratories to generate laboratory results. It also presents perspectives on how laboratory data interpretation is used in diagnosis and overall clinical case management.
- II: presents hematology and hemopathology of common domestic species. This includes all aspects of the hemogram or complete blood count, bone marrow, hemostasis, and transfusion medicine.
- III: presents hematology of common nondomestic species encountered in veterinary practice.
- IV: presents clinical chemistry of common domestic species and is organized primarily by organ system.
- V: presents clinical chemistry of common nondomestic species.
- VI: is a compilation of clinical cases. Each case includes a signalment, brief history, and pertinent physical examination findings. Then, relevant laboratory data are presented in tables followed by a narrative interpretation of the data.

**Revisions and additions**

Some of the more important revisions and additions include the following.

The overview of laboratory technology has been updated to reflect continued advances in and adoption of in-clinic diagnostic instrumentation and capabilities. Some of the historical laboratory procedures that are no longer used have been removed. Next, we comment on data interpretation skills. Our experience indicates that veterinarians are reasonably adept at understanding how laboratory tests relate to pathophysiology, but then don’t think probabilistically about the magnitude of data abnormalities and often struggle interpreting complex data sets. Rules for interpreting diagnostic tests assume homogeneity of pathophysiologic responses, or that our animal friends have “read the book”; as imagined in Figure P.1.

However, we know that there are many variables that create considerable biologic variability in expected responses. Chapter 3, Perspectives in Data Interpretation, has been revised to provide introductory guidance to build the skill set required for adroit interpretation of laboratory data. This involves development of flexible, probabilistic thinking skills when solving the complex puzzle formed by the array of clinical findings and laboratory data.

Extensive revision and some additions have been made possible for selected chapters by incorporation of content from new authors. Examples include:
Preface

• Robin Allison, Oklahoma State University, has made extensive revision of laboratory diagnostics related to pathology involving liver, pancreas, blood proteins, and muscle.
• Andrea Bohn and Glade Weiser, Colorado State University, have revised the often-dreaded subjects of electrolyte and acid-base pathology, with an attempt to simplify clinical understanding of these laboratory tests.
• Judy Radin, The Ohio State University, has provided a new chapter covering lipid pathology.
• Last, but not least, Don Meuten, North Carolina State University, brings his extensive experience and expertise cultivated from too many years in both anatomical and clinical pathology. He contributes new treatment of renal, endocrine, and calcium metabolic pathologies.

The Clinical Case Presentations were a separately bound supplement to the 1st Edition. In the 2nd Edition, the Clinical Case Presentations are incorporated into this single-bound textbook. These presentations are intended to provide students “practice” to develop interpretive skills by seeing examples of how data are interpreted into pathologic processes and how pathologic processes may culminate in a diagnostic scenario. The original cases are retained because their classical usefulness does not change. In addition, a number of new cases have been added by some of the new contributing authors.

It is our wish that readers not only learn principles and skills from this work, but also enjoy interacting with it. As veterinarians and specialists in bioanalytical pathology, we share our passion for the art and science of laboratory diagnostics applied to animal health.
Respectfully submitted,

Glade Weiser
Mary Anna Thrall
Robin Allison
Terry Campbell

Figure P.1 Dogs caught ‘reading the book’ in an attempt to make their disease responses predictable. Not all will read the book. (Courtesy of Dr. Sara Hill.)

• Wayne Jensen, Morris Animal Foundation, provides an update of the rapidly evolving area of immunodiagnostics.
• Advances have continued to be made in the diagnosis and classification of hematopoietic cell neoplasia. A new chapter from Anne Avery, Colorado State University, provides an overview of evolving molecular and flow cytometric diagnostics applied to hematopoietic neoplasia. This complements the other chapters detailing leukocyte responses, bone marrow evaluation, and hematopoietic proliferative disorders.
Preface to the First Edition

The publication of Veterinary Hematology and Clinical Chemistry marks a new and unique contribution to veterinary clinical pathology. The product of a collaborative effort by a team of experts in the field, this text combines critical information about performing diagnostic tests, viewing pertinent clinical pathology, and interpreting laboratory data with an innovative approach to incorporating color visual content.

Audience

A current trend in the field is the movement of laboratory diagnostics into the veterinary facility, enabled by technological advancements in point-of-care diagnostic capability. This movement to in-house testing increases the need for education in veterinary clinical pathology. Although this book was written primarily for veterinary students and practitioners, it has applications for a much broader audience, serving as a useful adjunct for the educational and reference needs of a variety of other users. The following audiences will benefit from this resource:

• Students in professional veterinary medical education programs
• Veterinary health professional teams in veterinary care facilities
• Veterinary clinical pathologists and clinical pathologists in training
• Research and product development groups utilizing veterinary clinical pathology

Organization

Veterinary Hematology and Clinical Chemistry is organized into six parts, arranged as follows:

• Part I presents principles of laboratory technology and test procedures used in veterinary labs to generate laboratory results.
• Part II presents hematology and hemopathology of common domestic species. This includes all aspects of the hemogram or complete blood count, bone marrow, hemostasis, and transfusion medicine.
• Part III presents hematology of common nondomestic species encountered in veterinary practice.
• Part IV presents clinical chemistry of common domestic species and is organized primarily by organ system.
• Part V presents clinical chemistry of common nondomestic species.

Unique art program

Many aspects of veterinary clinical pathology are highly visual. The most unique feature of this book is the quantity and quality of color artwork. This was facilitated by digital image acquisition and processing performed by the authors. Optimization and standardization of images was performed by digital image engineering techniques to achieve an improvement in imagery over what is possible with conventional photomicrography. Our goal was to bring a new level of realism to the visual communication of concepts pertaining to microscopy. In some instances, visual content has been amplified by combining images from multiple microscopic fields into a single figure or showing different levels of magnification within the same figure. Digital image engineering also allows for image manipulation; an example is arrangement of cells that are randomized on a microscope field into a specific order to convey a concept such as cell maturation. We believe that the fidelity of visual imagery, as well as its liberal integration with text content, makes this work the first of its kind.

Author team

Contributing content and expertise to this project are a number of recognized authorities in the field of veterinary clinical pathology. These individuals have helped shape the existing curriculum, train the existing faculty, and create the disciplines of comparative laboratory medicine and diagnostic cytology as we know them today. It is through the combined efforts of so many experts in the field that this book was made possible.

We hope you find this publication to be an excellent resource in the clinical laboratory and for laboratory data interpretation.

M. G. Weiser and M. A. Thrall
Fort Collins, Colorado
General Principles of Laboratory Testing and Diagnosis