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Serum creatinine concentration is insensitive for detecting kidney injury and does not assist in differentiation between glomerular versus tubular damage. Advanced renal function tests, including glomerular filtration rate testing, determining fractional excretion of electrolytes, and assay of urine biomarkers, may allow earlier detection of reduced renal function mass, differentiation of renal from non-renal causes of azotemia, and assist with localization of damage. This article reviews the principles, indications, and limitations of these tests and describes their use in sample clinical scenarios.	
<b>A Laboratory Diagnostic Approach to Hepatobiliary Disease in Small Animals</b>	<b>503</b>
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Routine biochemical tests generally include serum enzymes, proteins, and other markers useful for identifying hepatobiliary disease in dogs and cats. Obtaining results outside the reference intervals can occur with direct hepatocellular injury, enzyme induction by hepatocytes or biliary epithelium, or decreased hepatic function. However, detection of biochemical abnormalities does not necessarily indicate clinically significant disease. For a comprehensive approach to detection and treatment of hepatobiliary disease, the laboratory results must be correlated with the history and physical examination findings, diagnostic imaging results, and other assays.	
<b>Diagnosis of Small Intestinal Disorders in Dogs and Cats</b>	<b>521</b>
Karin Allenspach	
Laboratory tests are an important part of the workup of small intestinal diseases in dogs and cats. Especially in chronic cases, when extragastrointestinal causes need to be ruled out, it is important to adhere to a systematic workup. This article details the newest available data on tests to aid this diagnostic process. Once the diagnosis of a chronic enteropathy is made, there are many laboratory tests that can help in monitoring the disease and providing prognostic information. Several new tests being evaluated for clinical usefulness are discussed.	
<b>Practical Interpretation and Application of Exocrine Pancreatic Testing in Small Animals</b>	<b>535</b>
Caroline Mansfield	
The pancreas remains a difficult organ to evaluate using laboratory methods alone. No single laboratory test is diagnostic of pancreatitis (chronic or acute) without other diagnostic modalities concurring with the diagnosis or ruling out other diseases. The diagnosis of pancreatitis is particularly difficult in cats, and pancreatitis often occurs with other diseases. The use of pancreatic cytology may be useful in diagnosing both	

inflammation and neoplasia. Exocrine pancreatic insufficiency (EPI) can be relatively easily diagnosed when clinically manifested by the measurement of trypsinlike immunoreactivity. Diagnosis is more difficult when EPI is subclinical.

### **Using Cardiac Biomarkers in Veterinary Practice**

555

Mark A. Oyama

Blood-based assays for various cardiac biomarkers can assist in the diagnosis of heart disease in dogs and cats. The two most common markers are cardiac troponin-I and N-terminal pro-B-type natriuretic peptide. Biomarker assays can assist in differentiating cardiac from noncardiac causes of respiratory signs and detection of preclinical cardiomyopathy. Increasingly, studies indicate that cardiac biomarker testing can help assess the risk of morbidity and mortality in animals with heart disease. Usage of cardiac biomarker testing in clinical practice relies on proper patient selection, correct interpretation of test results, and incorporation of biomarker testing into existing diagnostic methods.

### **Use of Lactate in Small Animal Clinical Practice**

567

Leslie C. Sharkey and Maxey L. Wellman

Lactate is a product of anaerobic metabolism. Lactate concentration in blood is used clinically as an indicator of tissue hypoperfusion and hypoxia to determine disease severity, assess response to therapy, and predict outcome. This article reviews lactate physiology, sample collection and processing, and interpretation of lactate concentration in clinical practice.

### **Diagnosis of Disorders of Iron Metabolism in Dogs and Cats**

579

Andrea A. Bohn

Iron is an essential element and is used by every cell in the body. This article summarizes iron metabolism and disorders associated with iron metabolism in dogs and cats. The diagnostic tests currently in use for assessing iron status are discussed.

### **Making Sense of Lymphoma Diagnostics in Small Animal Patients**

591

Mary Jo Burkhard and Dorothee Bienzle

This article summarizes and compares the various assays available to aid in the diagnosis and characterization of lymphoma in small animal patients. These techniques include cytology, histopathology, immunocytochemistry and immunohistochemistry, immunophenotyping by flow cytometry, and polymerase chain reaction for clonal antigen receptor gene rearrangement.

### **Hematology of the Domestic Ferret (*Mustela putorius furo*)**

609

Stephen A. Smith, Kurt Zimmerman, and David M. Moore

Pet ferrets are presented to veterinary clinics for routine care and treatment of clinical diseases and female reproductive problems. In addition to obtaining clinical history, additional diagnostic testing may be required, including hematological assessments. This article describes common

blood collection methods, including venipuncture sites, volume of blood that can be safely collected, and handling of the blood. Hematological parameters for normal ferrets are provided along with a description of the morphology of ferret leukocytes to assist in performing a differential count.

**Hematological Assessment in Pet Rabbits: Blood Sample Collection and Blood Cell Identification** 617

David M. Moore, Kurt Zimmerman, and Stephen A. Smith

Pet rabbits are presented to veterinary clinics for routine care and treatment of clinical diseases. In addition to obtaining clinical history, additional diagnostic testing may be required, including hematological assessments. This article describes common blood collection methods, including venipuncture sites, volume of blood that can be safely collected, and handling of the blood. Hematological parameters for normal rabbits are provided for comparison with in-house or commercial test results. A description of the morphology of rabbit leukocytes is provided to assist in performing a differential count. Differential diagnoses are provided for abnormal values identified in the hemogram.

**Hematologic Assessment in Pet Rats, Mice, Hamsters, and Gerbils: Blood Sample Collection and Blood Cell Identification** 629

Nicole M. Lindstrom, David M. Moore, Kurt Zimmerman, and Stephen A. Smith

Hamsters, gerbils, rats, and mice are presented to veterinary clinics and hospitals for prophylactic care and treatment of clinical signs of disease. Physical examination, history, and husbandry practice information can be supplemented greatly by assessment of hematologic parameters. As a resource for veterinarians and their technicians, this article describes the methods for collection of blood, identification of blood cells, and interpretation of the hemogram in mice, rats, gerbils, and hamsters.

**Hematological Assessment in Pet Guinea Pigs (*Cavia porcellus*): Blood Sample Collection and Blood Cell Identification** 641

Kurt Zimmerman, David M. Moore, and Stephen A. Smith

Pet guinea pigs are presented to veterinary clinics for routine care and treatment of clinical diseases. In addition to obtaining clinical history, diagnostic testing may be required, including hematological assessments. This article describes common blood collection methods, including venipuncture sites, the volume of blood that can be safely collected, and handling of the blood. Hematological parameters for normal guinea pigs are provided for comparison with in-house or commercial test results. A description of the morphology of guinea pig leukocytes is provided to assist in performing a differential count.

**Avian Hematology** 649

Michael P. Jones

Avian veterinarians often rely heavily on the results of various diagnostic tests, including hematology results. As such, cellular identification and evaluation of the cellular response are invaluable tools that help

veterinarians understand the health or condition of their patient, as well as to monitor severity and clinical progression of disease and response to treatment. Therefore, it is important to thoroughly understand how to identify and evaluate changes in the avian erythron and leukon, as well as to interpret normal and abnormal results.

### **Reptile Hematology**

661

John M. Sykes IV and Eric Klaphake

The basic principles of hematology used in mammalian medicine can be applied to reptiles. The appearances of the blood cells are significantly different from those seen in most mammals, and vary with taxa and staining method used. Many causes for abnormalities of the reptilian hemogram are similar to those for mammals, although additional factors such as venipuncture site, season, hibernation status, captivity status, and environmental factors can also affect values, making interpretation of hematologic results challenging. Values in an individual should be compared with reference ranges specific to that species, gender, and environmental conditions when available.

### **Fish Hematology and Associated Disorders**

681

Krystan R. Grant

Fish health is a growing concern as pets, education, and aquaculture evolves. For the veterinary staff, fish handling, diagnostics, medicine, and surgery may require specialized training and equipment in comparison with terrestrial and arboreal animals, simply because of their aquatic nature and diversity. Fish hematology is one diagnostic tool that may not require additional equipment, may be inexpensive, and provide useful information in guiding treatment options. Challenges involving hematology may include handling and restraint, venipuncture, evaluation, and interpretation. In this article, strategies for these challenges are discussed for teleost (bony fish) and elasmobranch (cartilaginous fish) fish types.

### **Evaluation of the Blood Film**

703

Terry W. Campbell

Evaluation of hemic cell morphology in stained blood film may be the most important part of the hematologic evaluation of exotic animals. The blood film provides important information regarding red blood cell abnormalities, such as changes in cell shape and color, presence of inclusions, and, in the case of lower vertebrates, changes in the position of the cell nucleus. Stained blood film also provides information about changes in leukocyte numbers and morphology, and shows important hemic features of mammalian platelets and the thrombocytes of lower vertebrates. The blood film is needed in the detection and identification of blood parasites.