Plate 1. Photomicrographs of leukocyte abnormalities (all blood films stained with Wright stain) (5 μm bar in *L* applies to each frame).

A. Toxic band neutrophil with foamy cytoplasm that contains Döhle bodies, horse. **B.** Toxic neutrophil, dog. **C.** Toxic giant neutrophil with double nucleus and toxic band neutrophil, cat. **D.** Hypersegmented neutrophil, horse. **E.** Reactive lymphocyte, dog. **F.** Reactive lymphocyte, dog. **G.** Reactive lymphocyte, horse. **H.** Reactive plasmacytoid lymphocyte, cat. **I.** Activated monocyte or macrophage, cat. **J.** Sideroleukocyte, dog. **K.** Erythrophage, foal with neonatal isoerythrolysis. **L.** Neutrophil containing bacterial bacilli, cat.

Plate 2. Photomicrographs of leukocyte abnormalities (all Wright-stained blood films unless otherwise stated) (5 μm bar in *L* applies to each frame).

A. Morula of *Ehrlichia ewingii* in a neutrophil, dog. **B.** Morulae of *Anaplasma phagocytophilum* in a neutrophil, horse (from ASVCP slide contributed by J.W. Harvey, 1983). **C.** Morula of *Ehrlichia canis* in a granular lymphocyte, Panótico Rápido dip stain, Brazilian dog, (blood film courtesy of Camilo Bulla, Michigan State University). **D.** Distemper inclusions in a neutrophil, dog (from ASVCP slide contributed by J.C. Tobey, 1993). **E.** Gametocyte of *Hepatozoon americanum* in a monocyte, dog (from ASVCP slide contributed by C.J. LeBlanc et al., 2002). **F.** Yeast stages of *Histoplasma capsulatum* in a neutrophil, cat. **G.** Negative-staining *Mycobacterium* sp. in a neutrophil, dog (from ASVCP slide contributed by H.W. Tvedten, 1988). **H.** Negative-staining *Mycobacterium* sp. in a monocyte, dog (from same slide as *G*). **I.** Tachyzoites of *Toxoplasma gondii* in a neutrophil, dog. **J.** Pelger-Huët neutrophil, dog. **K.** Spectacle form of Pelger-Huët neutrophil, dog. **L.** Pelger-Huët eosinophil, dog.

Plate 3. Photomicrographs of erythrocyte abnormalities (all Wright-stained blood films unless otherwise stated) (5 μm bar in *L* applies to each frame).

A. Rouleaux, horse. **B.** Agglutination, dog. **C.** Rubricytosis (metarubricyte and rubricyte) and polychromatophilic erythrocyte, dog. **D.** Ghost erythrocytes, dog. **E.** Hypochromic erythrocytes of Fe deficiency, dog. **F.** Aggregate reticulocytes, new methylene blue vital stain, dog. **G.** Reticulocytes (coarse and fine punctate), new methylene blue vital stain, cat. **H.** *Anaplasma marginale*, cow. **I.** *Anaplasma centrale*, cow. **J.** *Babesia canis*, dog. **K.** *Babesia gibsoni*, dog (from ASVCP slide contributed by A.R. Irizarry-Rovira et al., 1999). **L.** *Cytauxzoon felis*, cat.

Plate 4. Photomicrographs of erythrocyte abnormalities (all Wright-stained blood films unless otherwise stated) (5 μm bar in *L* applies to each frame).

A. Distemper inclusions, dog (from ASVCP slide contributed by D.C. Bernreuter, 1981). **B.** Distemper inclusions, Diff-Quik stain, dog (from ASVCP slide contributed by J.R. Duncan, 1981). **C.** *Mycoplasma wenyonii*, most detached from erythrocytes, cow (from ASVCP slide contributed by E.G. Welles et al., 1993). **D.** *Mycoplasma haemocanis*, dog. **E.** *Mycoplasma haemofelis*, cat. **F.** *Theileria buffeli*, cow. **G.** Basophilic stippling of plumbism, dog. **H.** Heinz bodies, cat. **I.** Heinz bodies, new methylene blue vital stain, cat. **J.** Hemoglobin crystal, dog. **K.** Howell-Jolly bodies, dog. **L.** Howell-Jolly body, ring variant, horse.

Plate 5. Photomicrographs of erythrocyte abnormalities (all Wright-stained blood films unless otherwise stated) (5 μm bar in *L* applies to each frame).

A. Refractile artifact, Diff-Quik stain with water in fixative, dog. **B.** Siderocytes with siderotic granules, dog. **C.** Macrocyte and resulting anisocytosis, horse. **D.** Leptocytic, hypochromic microcytes of Fe deficiency, dog. **E.** Normochromic and polychromatophilic microcytes of a portosystemic shunt, dog. **F.** Poikilocytes including an elongated form (*lower center*) and a cell with a broad appendage (*upper center*), cat. **G.** Acanthocytes, splenic hemangiosarcoma, dog. **H.** Codocytes, dog. **I.** Dacryocyte, dog. **J.** Artifactual dacryocytes, dog. **K.** Eccentrocytes, horse. **L.** Echinocytes, dog.

Plate 6. Photomicrographs of erythrocyte abnormalities (all Wright-stained blood films unless otherwise stated) (5 μm bar in *L* applies to each frame).

A. Prekeratocytes (*left*) and keratocyte (*right*), dog. **B.** Folded, hypochromic, microcytic leptocyte of Fe deficiency, dog. **C.** Ovalocytes, dog. **D.** Pincered cells, dog. **E.** Pyknocyte (4 o'clock), horse. **F.** Pyknocytes, new methylene blue vital stain, horse. **G.** Schizocytes, dog. **H.** Selenocytes (artifacts), Diff-Quik stain, dog. **I.** Spherocytes, immune-mediated hemolytic anemia, dog. **J.** Acanthocytes and fragmentation-derived spherocytes, dog. **K.** Stomatocytes, dog (from ASVCP slide contributed by D.E. Brown et al., 1992). **L.** Torocytes (artifact), dog.

Plate 7. Photomicrographs of erythrocytes in a saline dispersion test, and platelet abnormalities in Wright-stained blood films (scale bar in each frame).

A. Marked rouleaux, 1 part blood to 1 part saline, nonstained wet preparation, dog. **B.** Rouleaux, 1 part blood in *A* to 3 parts saline, nonstained wet preparation. **C.** Absence of rouleaux, 1 part blood in *A* to 9 parts saline, nonstained wet preparation. **D.** Megakaryocyte in feathered edge of blood film, dog. **E.** Elongated platelet (proplatelet), cow. **F.** Oval and elongated platelets, fresh citrated blood, dog. **G.** Platelet density seen with a normal platelet concentration, dog. **H.** Platelet density seen with thrombocytopenia, dog. **I.** Platelet density seen with marked thrombocytosis due to essential thrombocythemia, dog (from ASVCP slide contributed by C.P. Mandell et al., 1987). **J.** Large platelet clump in feathered edge of blood film, cow. **K.** Smaller platelet clump surrounded by leukocytes and erythrocytes in feathered edge of blood film, cow. **L.** Small platelet clump in body of blood film, dog.

Plate 8. Photomicrographs of platelet abnormalities in Wright-stained blood films (5 μm bar in *L* applies to each frame).

A. Activated giant platelet with pseudopods and centralized granules, cat. **B.** Cluster of four activated, degranulated platelets, cat. **C.** Giant activated platelet with pseudopods and centralized granules, Cavalier King Charles spaniel. **D.** Giant platelet, unactivated, dog. **E.** *Anaplasma platys* morulae in platelets, Panótico Rápido dip stain (*all four quarters*), dog (slide courtesy of C. Lucidi, Universidade Estadual Paulista, Botucatu, Brazil). **F.** Platelet containing a probable fragment of nuclear material that can be mistaken for an organism, dog. **G.** Abnormal giant and hypogranular platelet associated with megakaryocytic leukemia (M7), dog (from ASVCP slide contributed by J. Messick et al., 1989). **H.** Megakaryoblast with cytoplasmic blebs, megakaryocytic leukemia (M7), dog (from same slide as *G*). **I.** Megakaryoblasts, megakaryocytic leukemia M7), dog (from ASVCP slide contributed by M. Ameri et al., 2006). **J.** Monocyte containing phagocytized platelet (rare finding), immune-mediated thrombocytopenia, dog. **K.** *Trypanosoma cruzi*, dog (from slide contributed by P.K. Penny et al., 2006). **L.** *Trypanosoma theileri*, cow (from ASVCP slide contributed by H. Bender et al., 1989).

Plate 9. Photomicrographs of cells and other microscopic findings in marrow samples; major reason for image is provided (all Wright-stained films of marrow aspirates unless otherwise stated) (scale bar in *O* applies to all frames except inserts and frames with separate scale bars).

A. Promegakaryocyte, dog. **B.** Mature megakaryocyte and smaller immature megakaryocyte, dog. **C.** Erythroid 'island' of nucleated erythroid series, dog. **D.** Granulocytic series from late myeloblasts to segmented neutrophil, dog. **E.** Hypercellular marrow fragment with darkly stained hemosiderin, high magnification insert with nonstained golden hemosiderin, dog. **F.** Marrow fragment with decreased hematopoietic cellularity, dog. **G.** Macrophages with engulfed rubriblast and degraded cell (*left*) and polychromatophilic rubricyte (*right*) associated with immune-mediated nonregenerative anemias, dogs. **H.** Myelofibrosis with bundles of fibrocytes and collagen, marrow core, hematoxylin and eosin stain, dog. **I.** Macrophage laden with amastigotes of *Leishmania* sp., insert with high magnification of amastigotes and their rod-shaped kinetoplasts, dog. **J.** Undifferentiated blast cells of acute leukemia, dog. **K.** Dysplastic myelomonocytic cells, cat. **L.** Dysplastic erythroid cells (*left* and *right*), cat. **M.** Dysplastic megakaryocyte with hyposegmented nucleus and mature cytoplasm (micromegakaryocyte), cat. **N.** Pleomorphic neoplastic plasma cells, multiple myeloma, dog. **O.** Neoplastic histiocytic cells with phagocytized neutrophil (*top left*), phagocytized rubricyte (*bottom left*), and large cell with atypical nucleoli (*right*), histiocytic sarcoma, dog.

Plate 10. Photomicrographs of cells and other microscopic findings in lymph node aspirates or imprints (except *O*); major reason for image is provided (all Wright-stained films of aspirates or imprints unless otherwise stated) (scale bar in *N* applies to all frames except *O*).

A. Predominantly small and intermediate lymphocytes, expected findings in health, dog. **B.** Plasma cells, large lymphocyte, and small lymphocytes, reactive lymph node, dog. **C.** Plasma cells, neutrophils, eosinophil, and small lymphocytes, reactive lymphadenitis, dog. **D.** Neutrophils, reactive intermediate lymphocyte, small lymphocytes, neutrophilic lymphadenitis, dog. **E.** Macrophages and neutrophils laden with nonstaining *Mycobacterium* sp., mycobacterial lymphadenitis, cat. **F.** *Histoplasma capsulatum* in a macrophage and extracellularly, high magnification insert of *Histoplasma* yeasts, fungal lymphadenitis. **G.** Budding yeast of *Blastomyces dermatitidis* and many neutrophils in different focal plane, fungal lymphadenitis, dog. **H.** *Leishmania* sp. amastigotes in neutrophils and macrophages, high magnification insert shows intracellular amastigotes with rod-shaped kinetoplasts, protozoal lymphadenitis, dog. **I.** Intermediate and large neoplastic lymphocytes, lymphoma, dog. **J.** Cell death of neoplastic lymphocytes 1 d after glucocorticoid therapy, lymphoma, dog. **K.** Small to intermediate neoplastic lymphocytes, lymphoma, dog. **L.** Small raft of pleomorphic epithelial cells, metastatic carcinoma, dog. **M.** Metastatic mast cells, eosinophils, and lymphocytes, dog. **N.** Neoplastic myeloid cells, metastatic myeloid leukemia (granulocytic sarcoma), dog. **O.** Secretory epithelial cells of mandibular salivary gland and windrowing of erythrocytes in the mucoid salivary fluid, salivary gland aspirate (attempted lymph node aspirate), dog.

Plate 11. Photograph of urine (*A*) and photomicrographs of urine sediment findings (*B–L*). Sediment was unstained except when air-dried (*D*). All wet

sediment photomicrographs were taken using a high-dry objective (use scale bar in frame *L*) except for *G*, which was taken using a 10× objective (grey scale bar).

A. USG_{ref} and osmolality of urine samples with different gross appearances and colors demonstrating that appearance does not necessarily predict USG_{ref} or solute concentration: (*1*) colorless, USG_{ref} = 1.014, osmolality = 410 mmol/kg; (*2*) light yellow, USG_{ref} = 1.014, osmolality = 531 mmol/kg; (*3*) yellow, USG_{ref} = 1.013, osmolality = 292 mmol/kg; and (*4*) dark yellow, USG_{ref} = 1.023, osmolality = 551 mmol/kg. **B.** Leukocytes and erythrocytes. **C.** Erythrocytes. **D.** Erythrocytes, three leukocytes, and clusters of bacterial cocci, no stain (*left*); erythrocytes and neutrophils with intracellular and extracellular clusters of bacterial cocci, air-dried cytocentrifuge preparation of sediment, Wright-stain (*right*), dog. **E.** Large bacterial rods and several leukocytes (courtesy of Don Schmidt, University of Missouri). **F.** Granular cast. **G.** Hyaline cast. **H.** Epithelial cell cast. **I.** Epithelial cell cluster (probably transitional epithelial cells). **J.** Squamous epithelial cells. **K.** Ammonium biurate crystals. **L.** Bilirubin crystals.

Plate 12. Serum protein electrophoresis densitometer tracings, cellulose acetate strips, and serum protein concentrations from dogs and cats. Reference intervals for total protein, albumin, and globulin concentrations for cats and dogs are in sections A and E, respectively.

A. Cat, healthy: The densitometer tracing is within expected results for healthy cats and is provided as a reference pattern; minor variations in the distribution of protein fractions would be found in other healthy cats.

B. Cat, panhyperproteinemia: The densitometer tracing is within expected results for a healthy cat but is found in a hyperproteinemic sample. Thus, protein concentrations are increased proportionately (panhyperproteinemia) and are consistent with hemoconcentration due to dehydration.

C. Cat, inflammatory dysproteinemia: The densitometer tracing shows a selective pattern—relatively less albumin compared to the globulin regions. Even though total globulin concentration is WRI, there are relatively more of α_2-globulin and γ-globulin fractions compared to the other globulin fractions. The increased α_2-globulin region is probably due to increased concentrations of haptoglobin or α_2-macroglobulin (positive acute-phase proteins). The increased γ-globulin region is broad-based and is thus due to a polyclonal gammopathy (probably mostly IgG). Overall, the dysproteinemia is a delayed-response pattern caused by an inflammatory process of more than 7 d duration.

D. Cat, inflammatory hyperproteinemia: The densitometer tracing shows a selective pattern—relatively less albumin compared to the globulin regions. The hyperglobulinemia is due to increased γ-globulin concentration. The increased γ-globulin region is narrow and thus could be a monoclonal gammopathy or a polyclonal gammopathy with restricted migration. In this case, a post mortem diagnosis of feline infectious peritonitis and the absence of B-lymphocyte neoplasia indicated that the hyperproteinemia, hypoalbuminemia, and hyperglobulinemia were due to chronic inflammation.

E. Dog, healthy: The densitometer tracing is within expected results for healthy dogs and is provided as a reference pattern; minor variations in the distribution of protein fractions would be found in other healthy dogs.

F. Dog, inflammatory hyperproteinemia: The densitometer tracing shows a selective pattern—relatively less albumin compared to the globulin regions. The hyperglobulinemia is due to increased β_2- and γ-globulin concentrations. This broad-based region represents a pronounced polyclonal gammopathy. In this case, clinical signs and an extremely high titer to *Ehrlichia canis* indicated that the hyperproteinemia was due to a chronic rickettsial (bacterial) infection.

G. Dog, β_2-monoclonal gammopathy: The densitometer tracing shows a selective pattern—relatively less albumin compared to the globulin regions. The hyperglobulinemia is due to increased β_2-globulin concentration. The β_2-globulin region is contains a narrow peak and an anodal shoulder. The combination of narrow β_2-globulin region and an apparent decrease in the γ-globulin concentration is indicative of a monoclonal gammopathy of a non-IgG immunoglobulin. This dog's hyperproteinemia was due to a myeloma and the serum IgA concentration was markedly increased.

H. Dog, panhypoproteinemia: The densitometer tracing is within expected results for a healthy dog but is found in a hypoproteinemic sample. Thus, protein concentrations are decreased proportionately (panhypoproteinemia). Causes of panhypoproteinemia include acute blood loss, maldigestive and malabsorptive disorders, starvation, cachexia, and occasionally hepatic failure. This dog had intestinal lymphoma.

I. Dog, selective hypoproteinemia and glomerular proteinuria

1. Serum: The densitometer tracing shows a selective pattern—relatively less albumin compared to the globulin regions. In a hypoproteinemic sample, this selective pattern indicates that albumin concentration is decreased more than some globulin concentrations. Even though the total globulins concentration is decreased, the relative excess of α_2-globulin region indicates that concentrations of other globulin fractions decreased more than the α_2-globulin concentration. This pattern is indicative of protein-losing nephropathy in which the glomerular filtration barrier has become more permeable to plasma proteins because of glomerulonephritis or glomerular amyloidosis. In such cases, there is a relative excess of the α_2-globulin region because α_2-macroglobulin is too large to pass through the filtration barrier but smaller proteins can. Note that even though there is hypoproteinemia, hypoalbuminemia, and hypoglobulinemia, there was not truly a panhypoproteinemia because the concentration of α_2-globulins was not decreased.
2. Urine: The densitometer tracing shows that most urine proteins are in the albumin region, consistent with a protein-losing nephropathy with a glomerular proteinuria. Note that the proteinuria is a selective proteinuria as the urine protein pattern is not the same as the dog's serum protein pattern.

J. Dog, non-selective hypoproteinemia and Bence Jones proteinuria

1. Serum: The densitometer tracing is within expected results for a healthy dog but is found in a hypoproteinemic sample. Thus, protein concentrations are decreased proportionately (panhypoproteinemia). Causes of panhypoproteinemia include acute blood loss, maldigestive and malabsorptive disorders, starvation, cachexia, and occasionally hepatic failure. This dog had multicentric lymphoma with Mott cells and its hypoproteinemia was probably due to multiple processes.
2. Urine: Most urine proteins are in the β_2-globulin region, consistent with migration of immunoglobulin light chains. The Bence Jones urine test was positive; that is, urine supernatant was initially clear, formed precipitate at 40–60 °C, cleared at 100 °C, and then appearances reversed as the sample returned to room temperature. Note that the proteinuria is a selective proteinuria as the urine protein pattern is not the same as the dog's serum protein pattern and represents one type of a prerenal proteinuria (see Chapter 8).

Note: The serum total protein and albumin concentrations were measured by biuret and BCG methods, respectively. The serum globulin concentrations were calculated by subtraction from the measured values. When the electrophoresis strips were scanned, the densitometer was set so that the darkest protein band in the sample caused the maximum deflection of the tracing pen. Hyperproteinemic samples were diluted (either 1 part serum to 1 part saline or 3 parts saline) prior to electrophoresis so that there was a more linear relationship between quantity of protein in the darkest band and the amount of light that passes through the strip. The urine total protein concentrations were measured by the Coomassie brilliant blue assay. The urine samples were concentrated 10-fold prior to electrophoresis.

Plate 13. Photomicrographs of direct urine sediment findings. Sediment was unstained except where noted (*I*). All photomicrographs were taken using a high-dry objective (use scale bar in frame *L*) except for *E*, which was taken using a 10× objective (grey scale bar).

A. Calcium carbonate crystals. **B.** Calcium oxalate dihydrate crystals and bacteria. **C.** Calcium oxalate monohydrate crystals. **D.** Cholesterol crystals (courtesy of Don Schmidt). **E.** Struvite crystals. **F.** Sulfa crystals and erythrocytes (courtesy of Don Schmidt). **G.** Uric acid crystals. **H.** Yeast. **I.** *Blastomyces* sp. and several neutrophils, new methylene blue stain. **J.** *Capillaria* sp. ovum (courtesy of Don Schmidt). **K.** Lipid droplets. **L.** Sperm.

Plate 14. Photomicrographs of cells and other microscopic findings in direct smears (*C*, *G*, *J*, and *N*) or cytocentrifuge preparations of cavitary effusions; erythrocytes are not described unless of major significance (all Wright-stained unless otherwise stated) (scale bar in *O* applies to all frames unless a frame has a separate scale bar).

A. Nondegenerate neutrophils and macrophages, peritoneal fluid, horse. **B.** Nondegenerate neutrophils and macrophages including two leukophages, peritoneal fluid, horse. **C.** Filamentous, beaded, branching (*upper area*) bacilli and small bacilli, consistent with *Actinomyces* sp. or *Nocardia* sp. (*left*), mildly degenerate neutrophils with phagocytized bacteria (*right*), pleural bacterial exudate, dog. **D.** Degenerate neutrophils (some containing short chains of cocci)

and mature squamous cell, peritoneal bacterial exudate, ruptured stomach, foal. **E.** Small lymphocytes, mast cell, and macrophage containing hemosiderin (siderophage), lymphoid pleural effusion, dog. **F.** Plasma cell and vacuolated macrophages, pleural effusion, dog. **G.** Neoplastic granular lymphocytes (*left* and *right*), neoplastic lymphoid peritoneal effusion, cat. **H.** Intermediate and large neoplastic lymphocytes, neoplastic lymphoid pleural effusion, dog. **I.** Small sheet of non-reactive mesothelial cells, neutrophils, and macrophages, peritoneal fluid, horse. **J.** Sheet of mesothelial cells, ox. **K.** Reactive mesothelial cell, nondegenerate neutrophils, and macrophage, pleural fluid, dog. **L.** Reactive mesothelial cells and nondegenerate neutrophils, pleural fluid, dog. **M.** Erythrophages and many erythrocytes, hemorrhagic peritoneal effusion, dog. **N.** Neutrophils and macrophage containing barium, foreign body peritoneal exudate, cat (slide courtesy of Jenny Thomas, Michigan State University). **O.** Nondegenerate neutrophils and macrophages with intracellular and extracellular particulate clot activator from collecting fluid into an activator-containing clot tube (in vitro phagocytosis), peritoneal fluid, cat.

Plate 15. Photomicrographs of cells and other findings in direct or cytocentrifuge (*A, H, K–M* and *O*) preparations of cavitary effusions; erythrocytes are not described (Wright-stained unless otherwise stated) (scale bar in *O* applies to all frames unless a frame has a separate scale bar).

A. Mostly eosinophils and blue fibrinous material consistent with clotting, eosinophilic exudate, cat. **B.** Pleomorphic large cells, neoplastic effusion, metastatic mammary carcinoma, dog. **C.** Pleomorphic large mesothelial cells, neoplastic effusion, mesothelioma, horse. **D.** Squamous epithelial cells and neutrophils, neoplastic effusion with exudation, gastric squamous cell carcinoma, horse (ASVCP slide contributed by M.J. Burkhard et al., 1995). **E.** Mostly degenerate neutrophils (one containing bacilli), bacterial exudate, dog. **F.** Mostly neutrophils (one containing morulae—another morula magnified in inserted image), exudate with *Anaplasma phagocytophilum*, horse (ASVCP slide contributed by D. Wood et al., 2001). **G.** Pseudohyphae of *Candida* sp. and damaged adherent cells, pericardial mycotic exudate, dog. **H.** Intestinal protozoa (*left* and *right*), bacterial peritoneal exudate due to intestinal rupture, horse. **I.** Calcium carbonate crystals and nucleated cells (out of focus), equine uroperitonium (ASVCP slide contributed by L. Vap et al., 1994). **J.** Sperm heads in neutrophils, exudate of seminoperitoneum, mare (ASVCP slide contributed by P. McWilliams, 1992). **K.** Bile pigment, neutrophils, and macrophages, bile peritonitis, dog. **L.** Small lymphocytes, nondegenerate neutrophils, and macrophages, insert with Sudanophilic lipid in and adjacent to macrophage, chylous effusion, cat. **M.** Vacuolated macrophages and nondegenerate neutrophils, exudate, pancreatitis, dog. **N.** Macrophages, granular protein and protein crescents, proteinaceous exudate, feline infectious peritonitis, cat. **O.** Nucleated and anucleated squamous epithelial cells, amnionic fluid collected during attempted abdominocentesis, alpaca.