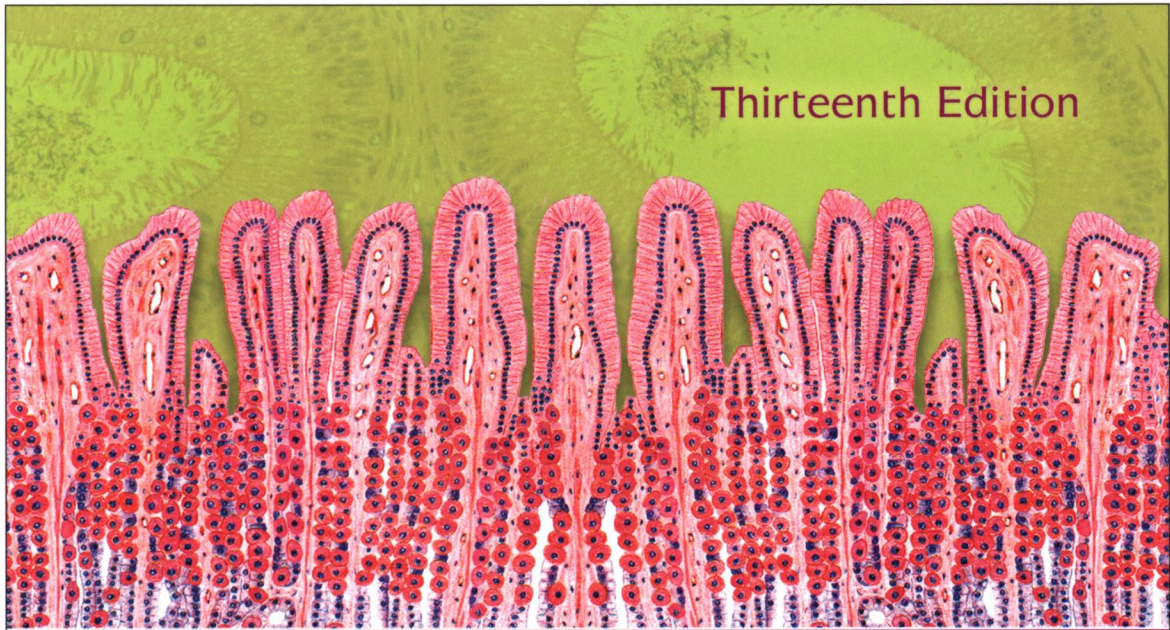


INTERNATIONAL EDITION

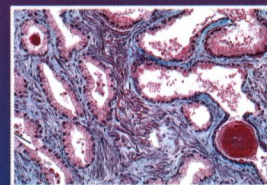
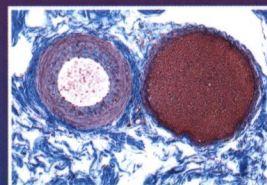
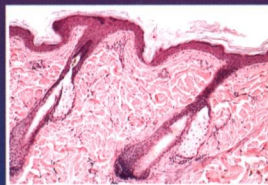
Not authorised for sale in United States, Canada, Australia, New Zealand, Puerto Rico or the U.S. Virgin Islands

Thirteenth Edition



ATLAS OF HISTOLOGY

with Functional Correlations



 Wolters Kluwer

Victor P. Eroschenko

 Wolters Kluwer

HISTOLOGY

Thirteenth Edition

ATLAS OF HISTOLOGY

with Functional Correlations

Victor P. Eroschenko, PhD

**Master histology
with idealized & actual
photomicrography!**

This thirteenth edition of *Atlas of Histology with Functional Correlations* (formerly *diFiore's*) provides a rich understanding of the basic histology concepts that medical and allied health students need to know. Realistic, full-color illustrations as well as actual photomicrographs of histologic structures are complemented by concise discussions of their most important functional correlations.

- **Illustrated histology images** show the idealized view, while photomicrographs provide the actual view to help students hone their skills in identifying structures.
- **New and improved layout** helps students connect the morphology of a structure with its function.
- **Updated and expanded Functional Correlations** boxes integrated throughout chapters reflect new scientific information and interpretations.
- **NEW photomicrographs and electron micrographs** provide views of microanatomy as experienced in practice.
- **Bulleted Chapter Summaries** distill the most essential knowledge for rapid review.
- **NEW Additional Histologic Images sections** round out each chapter with supplemental photomicrographs and electron micrographs.
- **NEW Chapter Review Questions** allow students to assess their comprehension of each chapter with 375 questions and answers in the book and 250 more online in an Interactive Question Bank.

 Wolters Kluwer

LWW.com

ISBN-13: 978-1-4963-1023-1
ISBN-10: 1-4963-1023-3

This International Edition has been published expressly for the use of students outside of the United States, Canada, Australia, New Zealand, Puerto Rico or the U.S. Virgin Islands.

If you have purchased this book in the United States, Canada, Australia, New Zealand, Puerto Rico or the U.S. Virgin Islands, please note that this book has been imported without the authorisation of the Publisher or the Author, and is in violation of the Publisher's rights. The Publisher reserves the right to take legal action to protect its rights if importation of this book is found to violate these territorial restrictions.



Eroschenko

ATLAS OF HISTOLOGY

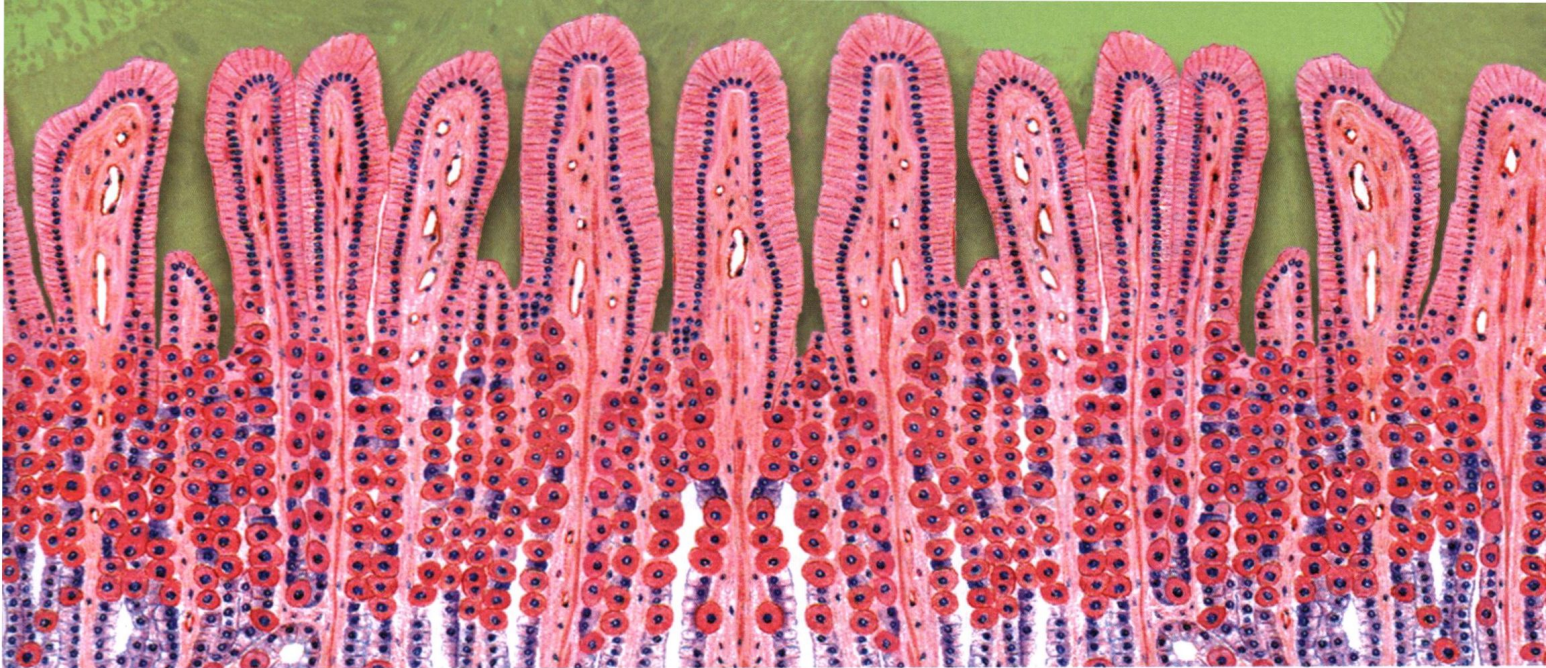
Eroschenko

With Functional Correlations

Thirteenth
Edition



Wolters
Kluwer



ATLAS OF HISTOLOGY

with Functional Correlations

Thirteenth Edition

Victor P. Eroschenko, PhD

Professor Emeritus of Anatomy

WWAMI Medical Program University of Idaho

Moscow, Idaho

 **Wolters Kluwer**

Philadelphia • Baltimore • New York • London
Buenos Aires • Hong Kong • Sydney • Tokyo

Not authorised for sale in United States, Canada, Australia, New Zealand, Puerto Rico, and U.S. Virgin Islands.

Acquisitions Editor: Crystal Taylor
Product Development Editor: Andrea Vosburgh
Editorial Coordinator: Annette Ferran
Marketing Manager: Michael McMahon
Designer: Terry Mallon
Production Project Manager: David Orzechowski
Compositor: SPi Global

Thirteenth Edition

Copyright © 2017 Wolters Kluwer

Copyright © 2013, 2009, 2005 Lippincott Williams & Wilkins, a Wolters Kluwer business.

351 West Camden Street
Baltimore, MD 21201

Two Commerce Square
2001 Market Street
Philadelphia, PA 19103

All rights reserved. This book is protected by copyright. No part of this book may be reproduced or transmitted in any form or by any means, including as photocopies or scanned-in or other electronic copies, or utilized by any information storage and retrieval system without written permission from the copyright owner, except for brief quotations embodied in critical articles and reviews. Materials appearing in this book prepared by individuals as part of their official duties as U.S. government employees are not covered by the above-mentioned copyright. To request permission, please contact Wolters Kluwer at Two Commerce Square, 2001 Market Street, Philadelphia, PA 19103, via email at permissions@lww.com, or via website at lww.com (products and services).

9 8 7 6 5 4 3 2 1

Printed in China

Library of Congress Cataloging-in-Publication Data

Names: Eroschenko, Victor P., author.

Title: Atlas of histology with functional correlations / Victor P. Eroschenko.

Other titles: DiFiore's atlas of histology with functional correlations

Description: 13th edition. | Philadelphia : Wolters Kluwer, [2017] | Preceded by DiFiore's atlas of histology with functional correlations / Victor P. Eroschenko. c2013.

Identifiers: LCCN 2016046552 | ISBN 9781496316769

Subjects: | MESH: Histology | Atlases

Classification: LCC QM557 | NLM QS 517 | DDC 611/.018—dc23 LC record available at <https://lccn.loc.gov/2016046552>

This work is provided “as is,” and the publisher disclaims any and all warranties, express or implied, including any warranties as to accuracy, comprehensiveness, or currency of the content of this work.

This work is no substitute for individual patient assessment based upon healthcare professionals' examination of each patient and consideration of, among other things, age, weight, gender, current or prior medical conditions, medication history, laboratory data and other factors unique to the patient. The publisher does not provide medical advice or guidance and this work is merely a reference tool. Healthcare professionals, and not the publisher, are solely responsible for the use of this work including all medical judgments and for any resulting diagnosis and treatments.

Given continuous, rapid advances in medical science and health information, independent professional verification of medical diagnoses, indications, appropriate pharmaceutical selections and dosages, and treatment options should be made and healthcare professionals should consult a variety of sources. When prescribing medication, healthcare professionals are advised to consult the product information sheet (the manufacturer's package insert) accompanying each drug to verify, among other things, conditions of use, warnings and side effects and identify any changes in dosage schedule or contraindications, particularly if the medication to be administered is new, infrequently used or has a narrow therapeutic range. To the maximum extent permitted under applicable law, no responsibility is assumed by the publisher for any injury and/or damage to persons or property, as a matter of products liability, negligence law or otherwise, or from any reference to or use by any person of this work.

LWW.com

ATLAS OF HISTOLOGY

with Functional Correlations

Thirteenth Edition

Dedicated

To those who matter so much

Cassidy

Declan

Beckett

Ian

McKenzie

Sarah

Shannon

and

Diane

Kathryn

Tatiana

Sharon

and

Todd

Joshua

Chadwick

and most especially and always

Elke

PREFACE TO THE THIRTEENTH EDITION

The thirteenth edition of *Atlas of Histology with Functional Correlations* (formerly *diFiore's Atlas of Histology with Functional Correlations*) continues to provide a colorful and expanded atlas of histologic images for medical, veterinary, dentistry, and pathology as well as students of the biological sciences.

As in previous editions, numerous comments from reviewers were helpful in suggesting improvement to the text and images of the atlas. Keeping these suggestions in mind, the composite and colorful illustrations of cells, tissues, and organs that made this atlas popular are maintained in the thirteenth edition. In addition, numerous photomicrographs were added throughout. While most of the images were prepared with light microscopy, other images with transmission and scanning microscopy are also included where it was necessary to show more precise and detailed morphology of different structures not visible with light microscopy.

The rapid advance in scientific research continues to produce volumes of new information that further our understanding of fundamental biological functions of cells as well as their subcellular and molecular components. Thus, in our contemporary era, the study of histology requires more than the recognition and identification of structural characteristics in different organs but also learning and understanding their diverse dynamics and functional correlations that maintain the homeostasis of living organisms.

CHANGES IN THE THIRTEENTH EDITION

- Descriptive text material has been carefully rewritten and updated for more concise presentation and easier understanding.
- Empty spaces have been condensed and replaced by text material and/or images.
- At least eight labeled Additional Histologic Images have been added to Chapters 2 and 3 through 22 to supplement the color illustrations and other histologic images.
- Chapters 2 through 22 now include five End-of-Chapter Review Questions with explanations for correct answers.
- The most important and latest functional correlations concerning the structure and function of various cells, tissues, and organs have been provided in a summarized format for easier reading and better comprehension of the new information.
- Composite lead-in art pages from previous editions have been dispersed throughout chapters to better correspond to their relevant topics.

LEARNING RESOURCES

The following Student and Instructor Resources are offered at Wolters Kluwer's learning resource center [thePoint®](#).

Student Resources:

- Interactive Question Bank of more than 250 additional multiple-choice questions not included in the book, with explanations for correct answers

Instructor Resources:

- Interactive Image Bank including all images from the book with labels and leaders on, labels and leaders off, and labels off with leaders on options

- Supplemental Image Bank including more than 1,000 additional unlabeled photomicrographs not included in the book, organized by chapter; multiple images of similar structures are included
- Syllabus Conversion Guide indicating changes and additions between the twelfth and thirteenth editions.

For more information about accessing and licensing Instructor Resources, please contact your sales representative or visit thepoint.lww.com.

ACKNOWLEDGMENTS

I acknowledge the numerous colleagues who have graciously contributed their images to my previous editions of this atlas. In this edition, the donated images are credited with their names and their affiliated institutions. I shall always be grateful to these professionals for their generosity and assistance in improving this atlas.

The cooperation and assistance provided by the staff of the publishing company of Wolters Kluwer is sincerely appreciated. As with numerous past editions, I acknowledge the assistance of Crystal Taylor, my long-time acquisitions editor. I also was given the high privilege of working for the third time in preparing this edition with the most professional freelance editor, Kelly Horvath. Her hard work and dedication to accuracy and the best possible production of this atlas is sincerely appreciated. To all other professional individuals who assisted or were involved in production of this latest version of my atlas I express my sincere appreciation.

IN MEMORIAM

Since assuming the authorship of this atlas approximately 30 years ago, I have had the pleasure of collaborating with Dr. E. Roland Brown, the medical illustrator who ensured the accurate composition of each histological illustration for this atlas during all of this time. These beautiful color illustrations of numerous cells and tissues made this atlas unique and popular with histology students. As I was preparing the atlas for the thirteenth edition, I was informed that Roland passed away. With Roland's death, the field of medical illustration has lost a very talented artist, and I have lost a close and wonderful friend. The beautiful histologic illustrations that he prepared for all previous editions of the atlas will be enjoyed and appreciated by many students worldwide for many years. His talent will be sorely missed.

Victor P. Eroschenko, PhD
Professor Emeritus of Anatomy
Eagle, Idaho
November 2016

REVIEWERS

FACULTY

Rebecca Brown
LeMoyne College
Syracuse, New York

Raymond Coleman
Cornell University
Ithaca, New York

John Kmetz
University of Texas at San Antonio
San Antonio, Texas

Regina Munro
Chandler-Gilbert Community College
Chandler, Arizona

Holly Ressetar
West Virginia University School of Medicine
Morgantown, West Virginia

STUDENTS

Josh Agranat
Boston University School of Medicine
Boston, Massachusetts

Cheri Dijamco
University of Texas Health Science Center at San Antonio
San Antonio, Texas

Reza Khorasanee
University of Oxford
Oxford, United Kingdom

Jason Lipof
George Washington University Medical School
Washington, District of Columbia

Tina Lu
University of California San Diego School of Medicine
San Diego, California

Andrew Mendelson
Lake Erie College of Osteopathic Medicine
Erie, Pennsylvania

Nicholas Pettit

American Association of Colleges of Osteopathic Medicine
Chevy Chase, Maryland

Hope Taitt

SUNY Downstate Medical Center
Brooklyn, New York

Jennifer Townsend

University of California San Francisco
San Francisco, California

Samuel Windham

University of Missouri School of Medicine
Columbia, Missouri

CONTENTS

Dedication v
Preface to the Thirteenth Edition vii
Reviewers ix

PART I Introduction

CHAPTER 1 HISTOLOGIC METHODS 2

SECTION 1 Tissue Preparation and Staining of Sections 2

SECTION 2 Histologic Slide Interpretation 4

- FIGURE 1.1** Kidney cortex with a renal corpuscle and different convoluted tubules. 4
- FIGURE 1.2** Skeletal muscle sectioned in the longitudinal plane and cross section with surrounding blue-staining connective tissue. 5
- FIGURE 1.3** Villus of a small intestine with brush border, columnar epithelium, and goblet cells. 5
- FIGURE 1.4** Section of a wall from the aorta, showing the presence of dark-staining elastic fibers and pink smooth muscles. 5
- FIGURE 1.5** Intramembranous ossification in skull bones showing blue connective tissue, red blood cells, and blood vessels with blood cells. 5
- FIGURE 1.6** Blood smear with different cells and platelets. 6
- FIGURE 1.7** Cross section of the spinal cord showing the gray and white matter. 6
- FIGURE 1.8** Cross section of a peripheral nerve showing the myelin sheath of the axons. 6
- FIGURE 1.9** Small artery and veins showing blood cells and the surrounding connective tissues. 6
- FIGURE 1.10** Planes of sections through a round object, a hard-boiled, solid egg. 7
- FIGURE 1.11** Planes of section through a hollow object, a tube. 8
- FIGURE 1.12** Tubules of the testis in different planes of section. 9

PART II Cell and Cytoplasm

CHAPTER 2 LIGHT AND TRANSMISSION ELECTRON MICROSCOPY 12

- FIGURE 2.1** Composite illustration of a cell, its cytoplasm, and its organelles. 13
- FIGURE 2.2** Composition of cell membrane. 14
- FIGURE 2.3** Internal and external morphology of ciliated and nonciliated epithelium. 20
- FIGURE 2.4** A junctional complex between epithelial cells. 21
- FIGURE 2.5** Basal regions of epithelial cells. 22
- FIGURE 2.6** Basal region of an ion-transporting cell. 23
- FIGURE 2.7** Cilia and microvilli. 24
- FIGURE 2.8** Nuclear envelope and nuclear pores. 25

- FIGURE 2.9** Mitochondria (longitudinal and cross section). 26
- FIGURE 2.10** Rough endoplasmic reticulum. 26
- FIGURE 2.11** Smooth endoplasmic reticulum. 27
- FIGURE 2.12** Golgi apparatus. 28
- FIGURE 2.13** Ultrastructure of lysosomes and residual bodies in the cytoplasm of a tissue macrophage. 29
- FIGURE 2.14** Cytoplasmic contents and organelles of a ciliated cell from an avian oviduct. 34
- FIGURE 2.15** Cell and cytoplasmic organelles in a cell from a rodent spinal cord. 34
- FIGURE 2.16** A section of a cell nucleus and the adjacent cytoplasmic organelles. 35
- FIGURE 2.17** A section of a ciliated cell cytoplasm exhibiting different organelles in the epithelium of an avian oviduct. 35
- FIGURE 2.18** Secretory cells with dense secretory granules in the apical regions of a gland from a section of an avian oviduct. 36
- FIGURE 2.19** Apical section of cells from the lining epithelium of an avian oviduct showing different cytoplasmic organelles. 36
- FIGURE 2.20** Transverse section of a secretory epithelium from an avian oviduct showing the developed rough endoplasmic reticulum. 37
- FIGURE 2.21** Secretory cell with dense secretory granules and the dilated rough endoplasmic reticulum in the glandular epithelium of an avian oviduct. 37

CHAPTER 3 CELLS AND THE CELL CYCLE 38

- FIGURE 3.1** Different phases of mitosis and cytokinesis. 40



PART III Tissues

CHAPTER 4 EPITHELIAL TISSUE 44

SECTION 1 Classification of Epithelial Tissue 44

- FIGURE 4.1** Different types of epithelia in selected organs. 45
- FIGURE 4.2** Simple squamous epithelium: surface view of peritoneal mesothelium. 47
- FIGURE 4.3** Simple squamous epithelium: peritoneal mesothelium surrounding the small intestine (transverse section). 48
- FIGURE 4.4** Different epithelial types in the kidney cortex. 49
- FIGURE 4.5** Simple columnar epithelium: surface of the stomach. 49
- FIGURE 4.6** Simple columnar epithelium on villi in the small intestine: cells with brush borders (microvilli) and goblet cells. 50
- FIGURE 4.7** Pseudostratified columnar ciliated epithelium: respiratory passages—trachea. 52
- FIGURE 4.8** Transitional epithelium: bladder (unstretched or relaxed). 53
- FIGURE 4.9** Transitional epithelium: bladder (stretched). 54
- FIGURE 4.10** Stratified squamous nonkeratinized epithelium: esophagus. 55
- FIGURE 4.11** Stratified squamous keratinized epithelium: palm of the hand. 56
- FIGURE 4.12** Stratified cuboidal epithelium: an excretory duct in the salivary gland. 57

SECTION 2 Classification of Glandular Tissue 60

- FIGURE 4.13** Unbranched simple tubular exocrine glands: intestinal glands. **A.** Diagram of the gland. **B.** Transverse section of the large intestine. 61
- FIGURE 4.14** Simple branched tubular exocrine gland: gastric glands. **A.** Diagram of the gland. **B.** Transverse section of the stomach. 62

- FIGURE 4.15** Coiled tubular exocrine glands: sweat glands. **A.** Diagram of the gland. **B.** Transverse and three-dimensional view of a coiled sweat gland. **62**
- FIGURE 4.16** Compound acinar exocrine gland: mammary gland. **A.** Diagram of the gland. **B and C.** A mammary gland during lactation. **63**
- FIGURE 4.17** Compound tubuloacinar (exocrine) gland: salivary gland. **A.** Diagram of the gland. **B.** A submandibular salivary gland. **63**
- FIGURE 4.18** Compound tubuloacinar (exocrine) gland: submaxillary salivary gland. **64**
- FIGURE 4.19** Endocrine gland: pancreatic islet. **A.** Diagram of a pancreatic islet. **B.** High magnification of the endocrine and exocrine pancreas. **65**
- FIGURE 4.20** Endocrine and exocrine pancreas. **66**
- FIGURE 4.21** Simple cuboidal and simple squamous epithelium in different tubules of a rodent kidney. **69**
- FIGURE 4.22** Simple columnar and simple squamous epithelia in the papillary region of a primate kidney. **69**
- FIGURE 4.23** Simple columnar epithelium with brush border, goblet cells, and lymphocytes in the connective tissue of a rodent intestinal villus. **70**
- FIGURE 4.24** Simple columnar epithelium exhibiting both ciliated and secretory cells overlying connective tissue with fibrocytes in a primate oviduct. **70**
- FIGURE 4.25** Stratified cuboidal epithelium lining the excretory duct of a primate salivary gland and surrounded by connective tissue fibers and cells. **71**
- FIGURE 4.26** Pseudostratified columnar epithelium with stereocilia surrounded by smooth muscle fibers in a primate epididymis. **71**
- FIGURE 4.27** Transitional epithelium in a relaxed primate bladder overlying connective tissue with fibrocytes. **72**
- FIGURE 4.28** Stratified squamous nonkeratinized (moist) vaginal primate epithelium with underlying connective tissue filled with numerous dark-staining lymphocytes. **72**

CHAPTER 5 CONNECTIVE TISSUE 73

- FIGURE 5.1** Composite illustration of loose connective tissue with its predominant cells and fibers. **74**
- FIGURE 5.2** Loose connective tissue (spread). Stained for cells and fibers. **77**
- FIGURE 5.3** Cells of the connective tissue. **78**
- FIGURE 5.4** A connective tissue, a capillary, and a mast cell in the mesentery of a small intestine. **79**
- FIGURE 5.5** Embryonic connective tissue. **79**
- FIGURE 5.6** Loose connective tissue with blood vessels and adipose cells. **80**
- FIGURE 5.7** Dense irregular and loose irregular connective tissue. **81**
- FIGURE 5.8** Dense irregular and loose irregular connective tissue. **81**
- FIGURE 5.9** Dense irregular connective tissue and adipose tissue. **82**
- FIGURE 5.10** Dense regular connective tissue: tendon (longitudinal section). **83**
- FIGURE 5.11** Dense regular connective tissue: tendon (longitudinal section). **84**
- FIGURE 5.12** Dense regular connective tissue: tendon (transverse section). **85**
- FIGURE 5.13** Adipose tissue in the intestine. **85**
- FIGURE 5.14** Mesenchymal tissue from a developing rodent fetus. **90**
- FIGURE 5.15** Whole mount section through a mesentery illustrating the loose connective tissue, elastic fibers, fibroblasts, and the abundant surrounding ground substance. **90**
- FIGURE 5.16** Loose connective tissue below the transitional epithelium in a section from a primate urethra. **91**
- FIGURE 5.17** Dense irregular connective tissue in a canine lip adjacent to white adipose cells (tissue). **91**

FIGURE 5.18 Dense regular connective tissue from a primate tendon illustrating the dense arrangement of collagen fibers and the compressed fibroblasts. **92**

FIGURE 5.19 Reticular fiber meshwork in a primate lymph node. **92**

FIGURE 5.20 A section of the wall from an aorta illustrating different connective tissue fibers and smooth muscle fibers. **93**

FIGURE 5.21 White adipose tissue (cells) adjacent to skeletal muscle fibers and dense irregular collagen fibers. Histologic preparation dissolved the lipids in the cell cytoplasm, showing only the nuclei. **93**

CHAPTER 6 HEMATOPOIETIC TISSUE 94

SECTION 1 Blood 94

FIGURE 6.1 Differentiation of myeloid and lymphoid stem cells into their mature forms and their distribution in the blood and connective tissue. **95**

FIGURE 6.2 Human blood smear: erythrocytes, neutrophils, eosinophils, a lymphocyte, and platelets. **97**

FIGURE 6.3 Human blood smear: RBCs, neutrophils, a large lymphocyte, and platelets. **98**

FIGURE 6.4 Erythrocytes and platelets in a blood smear. **98**

FIGURE 6.5 Neutrophils and a Barr body. **99**

FIGURE 6.6 Eosinophil. **100**

FIGURE 6.7 Lymphocytes. **100**

FIGURE 6.8 Monocyte. **101**

FIGURE 6.9 Basophil. **101**

FIGURE 6.10 Human blood smear: a basophil, a neutrophil, erythrocytes, and platelets. **103**

FIGURE 6.11 Human blood smear: a monocyte, erythrocytes, and platelets. **103**

FIGURE 6.12 Development of different blood cells in the red bone marrow (decalcified). **107**

SECTION 2 Bone Marrow 107

FIGURE 6.13 Bone marrow smear: development of different blood cell types. **109**

FIGURE 6.14 Bone marrow smear: selected precursors of different blood cells. **110**

FIGURE 6.15 Human blood smear showing different blood cells and cellular fragments, the platelets. **114**

FIGURE 6.16 Human blood smear exhibiting different blood cells and cell fragments. **114**

FIGURE 6.17 High magnification of a human blood smear showing two neutrophils with multilobar nuclei and some light-staining cytoplasmic granules. **115**

FIGURE 6.18 High magnification of a human blood smear showing an eosinophil with characteristic pink-staining eosinophilic cytoplasmic granules and bilobed nucleus. **115**

FIGURE 6.19 High magnification of a human blood smear showing a basophil with characteristic dark blue-staining cytoplasmic granules. **116**

FIGURE 6.20 High magnification of a human blood smear showing a large monocyte with characteristic "kidney-shaped" nucleus. **116**

FIGURE 6.21 High magnification of a human blood smear showing a seldom-seen large lymphocyte with a characteristic dense nucleus and a rim of visible, blue-staining cytoplasm. **117**

FIGURE 6.22 High magnification of a human blood smear showing a small lymphocyte with a dense blue nucleus occupying almost all of the cytoplasm. **117**