

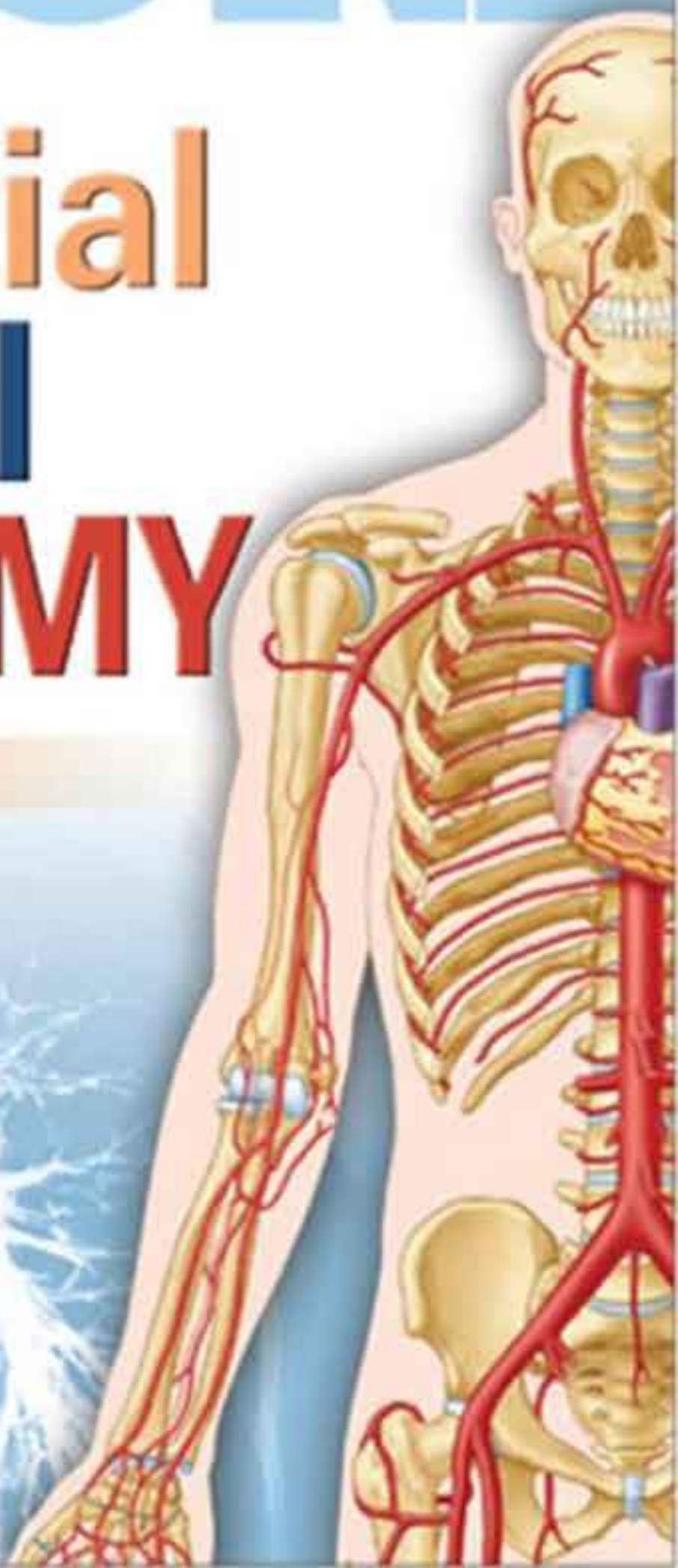
# MOORE

# Essential Clinical ANATOMY

Fifth Edition

Keith L. Moore  
Anne M.R. Agur  
Arthur F. Dalley

 Wolters Kluwer  
Health



**MIOORE**

**Essential**  
**Clinical**  
**ANATOMY**

Fifth Edition





# MOORE

## Essential Clinical ANATOMY

Fifth Edition

**Keith L. Moore, MSc, PhD, DSc, FIAC, FRSM, FAAA**

Professor Emeritus, Division of Anatomy, Department of Surgery  
Former Chair of Anatomy and Associate Dean for Basic Medical Sciences  
Faculty of Medicine  
University of Toronto  
Toronto, Ontario, Canada

**Anne M.R. Agur, BSc(OT), MSc, PhD**

Professor, Division of Anatomy, Department of Surgery, Faculty of Medicine  
Division of Psychiatry, Department of Medicine  
Department of Physical Therapy  
Department of Occupational Science & Occupational Therapy  
Division of Biomedical Communications, Institute of Medical Science  
Graduate Department of Rehabilitation Science  
Graduate Department of Dentistry  
University of Toronto  
Toronto, Ontario, Canada

**Arthur F. Dalley II, PhD**

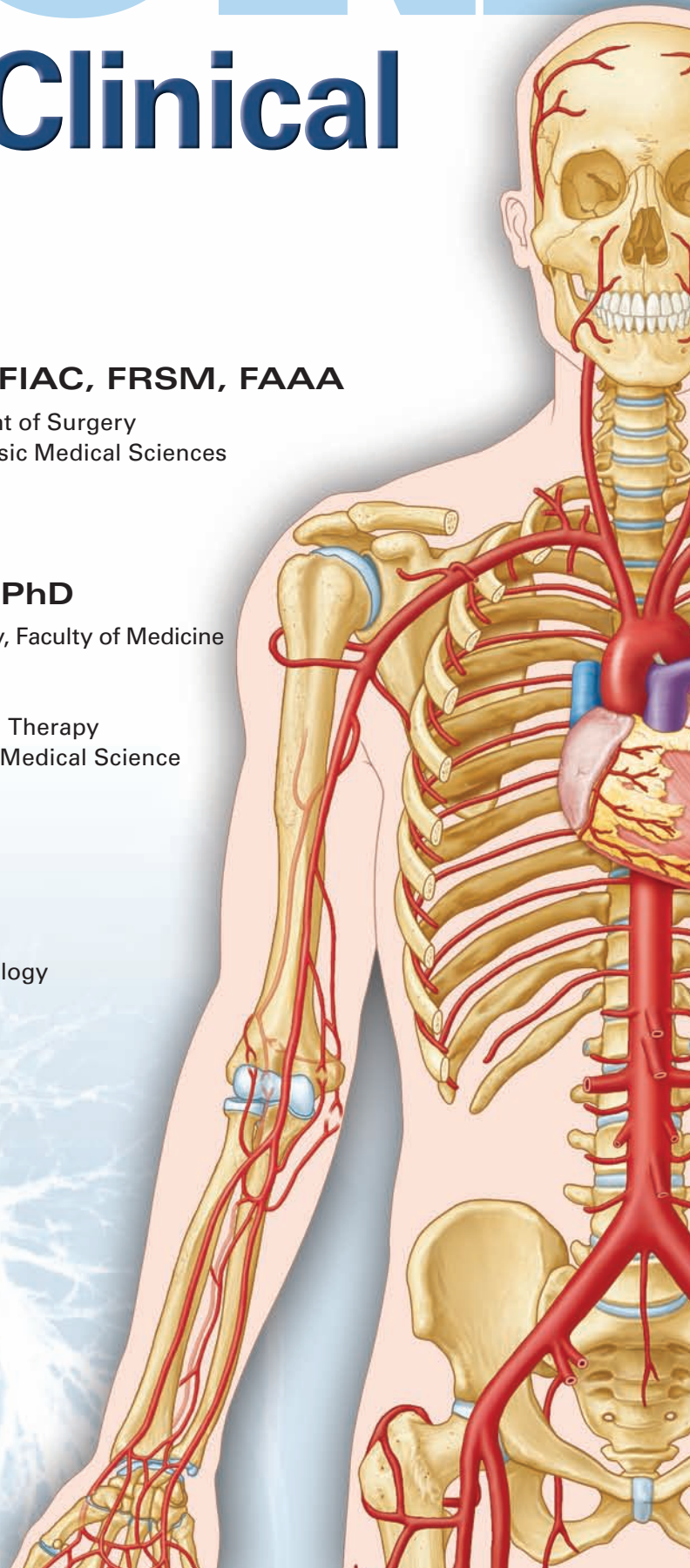
Professor, Department of Cell and Developmental Biology  
Adjunct Professor, Department of Orthopaedic  
Surgery and Rehabilitation  
Vanderbilt University School of Medicine  
Adjunct Professor for Anatomy  
Belmont University School of Physical Therapy  
Nashville, Tennessee, U.S.A.



Wolters Kluwer

Health

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 Manager: Julie Montalbano/Lauren Pecarich  
Marketing Manager: Joy Fisher Williams  
Art Director: Jennifer Clements  
Artist: Imagineeringart.com, lead artist Natalie Intven, MSc, BMC  
Compositor: Absolute Service, Inc.

5th Edition

Copyright © 2015, 2011, 2007, 2002, 1995 Lippincott Williams & Wilkins, a Wolters Kluwer business.

351 West Camden Street	Two Commerce Square
Baltimore, MD 21201	2001 Market Street
	Philadelphia, PA 19106

Printed in China

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 Lippincott Williams & Wilkins at Two Commerce Square, 2001 Market Street, Philadelphia, PA 19106, via email at [permissions@lww.com](mailto:permissions@lww.com), or via website at [lww.com](http://lww.com) (products and services).

#### Library of Congress Cataloging-in-Publication Data

Moore, Keith L., author.

Essential clinical anatomy / Keith L. Moore, Anne M.R. Agur, Arthur F. Dalley II. — Fifth edition.

p. ; cm.

Parent text: Clinically oriented anatomy / Keith L. Moore, Arthur F. Dalley, Anne M.R. Agur. 7th ed. c2014.

Includes bibliographical references and index.

ISBN 978-1-4511-8749-6 (paperback)

I. Agur, A. M. R., author. II. Dalley, Arthur F., II, author. III. Moore, Keith L. Clinically oriented anatomy. Digest of (work): IV. Title.

[DNLM: 1. Anatomy—Handbooks. QS 39]

QM23.2

611—dc23

2013049982

#### DISCLAIMER

Care has been taken to confirm the accuracy of the information present and to describe generally accepted practices. However, the authors, editors, and publisher are not responsible for errors or omissions or for any consequences from application of the information in this book and make no warranty, expressed or implied, with respect to the currency, completeness, or accuracy of the contents of the publication. Application of this information in a particular situation remains the professional responsibility of the practitioner; the clinical treatments described and recommended may not be considered absolute and universal recommendations.

The authors, editors, and publisher have exerted every effort to ensure that drug selection and dosage set forth in this text are in accordance with the current recommendations and practice at the time of publication. However, in view of ongoing research, changes in government regulations, and the constant flow of information relating to drug therapy and drug reactions, the reader is urged to check the package insert for each drug for any change in indications and dosage and for added warnings and precautions. This is particularly important when the recommended agent is a new or infrequently employed drug.

Some drugs and medical devices presented in this publication have Food and Drug Administration (FDA) clearance for limited use in restricted research settings. It is the responsibility of the health care provider to ascertain the FDA status of each drug or device planned for use in their clinical practice.

To purchase additional copies of this book, call our customer service department at **(800) 638-3030** or fax orders to **(301) 223-2320**. International customers should call **(301) 223-2300**.

Visit Lippincott Williams & Wilkins on the Internet: <http://www.lww.com>. Lippincott Williams & Wilkins customer service representatives are available from 8:30 am to 6:00 pm, EST.

*In Loving Memory of Marion*

*My best friend, wife, colleague, mother of our five children, and grandmother of our nine grandchildren for her love, unconditional support, and understanding.*

*Wonderful memories keep you in our hearts and minds.*

*—Keith L. Moore*

*To my husband, Enno, and my children, Erik and Kristina,  
for their support and encouragement.*

*—Anne M.R. Agur*

*To Muriel, my bride, best friend, counselor,  
and mother of our sons;*

*and to our family—Tristan, Lana, Elijah, Finley, and Sawyer; Denver and Skyler—with  
love and great appreciation for their support,  
understanding, good humor, and—most of all—patience.*

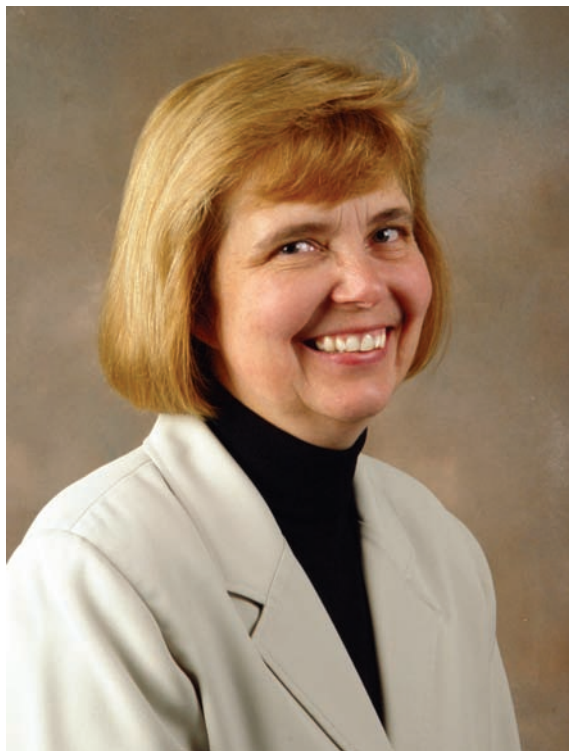
*—Arthur F. Dalley*

*And with sincere appreciation for the anatomical donors  
without whom our studies would not be possible.*



**KEITH L. MOORE,**  
MSc, PhD, DSc, FIAC, FRSM, FAAA

---



**ANNE M.R. AGUR,**  
BSc (OT), MSc, PhD

---



**ARTHUR F. DALLEY II,**  
PhD

---



# PREFACE

Nineteen years have passed since the first edition of *Essential Clinical Anatomy* was published. The main aim of the fifth edition is to provide a compact yet thorough textbook of clinical anatomy for students and practitioners in the health care professions and related disciplines. We have made the book even more student friendly. The presentations

- Provide a basic text of human clinical anatomy for use in current health sciences curricula
- Present an appropriate amount of clinically relevant anatomical material in a readable and interesting form
- Place emphasis on clinical anatomy that is important for practice
- Provide a concise clinically oriented anatomical overview for clinical courses in subsequent years
- Serve as a rapid review when preparing for examinations, particularly those prepared by the National Board of Medical Examiners
- Offer enough information for those wishing to refresh their knowledge of clinical anatomy

This edition has been thoroughly revised, keeping in mind the many invaluable comments received from students, colleagues, and reviewers. The key features include

- An extensively revised art program, giving the book an entirely new streamlined and fresh appearance. All of the illustrations are now in full color and designed to highlight important facts and show their relationship to clinical medicine and surgery. Each illustration has been reworked, whether for the seventh edition of *Clinically Oriented Anatomy (COA7)* or specifically for this book, to create a uniform and user-friendly product. A great effort has been made to further improve clarity of labeling and to place illustrations on the pages being viewed as the illustrations are cited in the text.
- Revised text with a stronger clinical orientation
- More illustrated clinical correlations, known as “blue boxes,” have been included to help with the understanding of the practical value of anatomy. In response to our readers’ suggestions, the blue boxes have been grouped. They are also classified by the following icons to indicate the type of clinical information covered:



**Anatomical variations icon.** These blue boxes feature anatomical variations that may be encountered in the dissection lab or in practice, emphasizing the clinical importance of awareness of such variations.



**Life cycle icon.** These blue boxes emphasize prenatal developmental factors that affect postnatal anatomy and anatomical phenomena specifically associated with stages of life—childhood, adolescence, adult, and advanced age.



**Trauma icon.** The effect of traumatic events—such as fractures of bones or dislocations of joints—on normal anatomy and the clinical manifestations and dysfunction resulting from such injuries are featured in these blue boxes.



**Diagnostic procedures icon.** Anatomical features and observations that play a role in physical diagnosis are targeted in these blue boxes.



**Surgical procedures icon.** These blue boxes address such topics as the anatomical basis of surgical procedures, such as the planning of incisions and the anatomical basis of regional anesthesia.



**Pathology icon.** The effect of disease on normal anatomy, such as cancer of the breast, and anatomical structures or principles involved in the confinement or dissemination of disease within the body are the types of topics covered in these blue boxes.

- Surface anatomy is integrated into the chapter at the time each region is being discussed to demonstrate the relationship between anatomy and physical examination, diagnosis, and clinical procedures.
- Medical images (radiographic, CT, MRI, and ultrasonography studies) have been included, often with correlative illustrations. Current diagnostic imaging techniques demonstrate anatomy as it is often viewed clinically.
- Case studies accompanied by clinico-anatomical problems and USMLE-style multiple-choice questions. Interactive case studies and multiple-choice questions are available to our readers online at <http://thePoint.lww.com/ECA5e>, providing a convenient and comprehensive means of self-testing and review.
- Instructor’s resources and supplemental materials, including images exportable for PowerPoint presentation, are available through <http://thePoint.lww.com/ECA5e>.

The terminology adheres to the *Terminologica Anatomica* (1998) approved by the International Federation of Associations of Anatomists (IFAA). The official English-equivalent terms are used throughout the present edition.



When new terms are introduced, however, the Latin forms as used in Europe, Asia, and other parts of the world appear in parentheses. The roots and derivation of terms are included to help students understand the meaning of the terminology. Eponyms, although not endorsed by the IFAA, appear in parentheses to assist students during their clinical studies.

The parent of this book, *Clinically Oriented Anatomy* (COA), is recommended as a resource for more detailed descriptions of human anatomy and its relationship and importance to medicine and surgery. *Essential Clinical Anatomy*, in addition to its own unique illustrations and manuscript, has utilized from the outset materials from *Clinically Oriented Anatomy* and *Grant's Atlas*.

We again welcome your comments and suggestions for improvements in future editions.

Keith L. Moore  
*University of Toronto*  
*Faculty of Medicine*

Anne M.R. Agur  
*University of Toronto*  
*Faculty of Medicine*

Arthur F. Dalley II  
*Vanderbilt University*  
*School of Medicine*



# ACKNOWLEDGMENTS

We wish to thank the following colleagues who were invited by the publisher to assist with the development of this fifth edition.

## List of Reviewers

Kacie Bhushan  
Nova Southeastern University  
Fort Lauderdale, Florida

Leonard J. Cleary, PhD  
Professor  
The University of Texas Health Science Center  
Medical School  
Houston, Texas

Alan Crandall, MS  
Idaho State University  
Pocatello, Idaho

Bertha Escobar-Poni, MD  
Loma Linda University  
Loma Linda, California

Thomas Gillingwater, PhD  
Professor of Neuroanatomy  
University of Edinburgh  
Edinburgh, United Kingdom

William Huber, PhD  
Professor  
St. Louis Community College at Forest Park  
St. Louis, Missouri

Lorraine Jadeski, PhD  
Associate Professor  
University of Guelph  
Ontario, Canada

Marta Lopez, LM, CPM, RMA  
Program Coordinator/Professor  
Medical Assisting Program  
Miami Dade College  
Miami, Florida

Yogesh Malam  
University College London  
London, United Kingdom

Volodymyr Mavrych, MD, PhD, DSc  
Professor  
St. Matthew's University  
Cayman Islands

Karen McLaren

Monica Oblinger, MS, PhD  
Professor  
Rosalind Franklin University of Medicine and Science  
North Chicago, Illinois

Onyekwere Onwumere, MA, MPhil  
Adjunct Faculty  
The College of New Rochelle  
New Rochelle, New York

Simon Parson, BSc, PhD  
Professor  
University of Edinburgh  
Edinburgh, United Kingdom

Gaurav Patel  
Windsor University School of Medicine  
Cayon, Saint Kitts

Ryan Splittgerber, PhD  
Assistant Professor  
University of Nebraska Medical Center  
Omaha, Nebraska

Christy Tomkins-Lane, PhD  
Assistant Professor  
Mount Royal University  
Calgary, Alberta, Canada

Victor Emmanuel Usen  
Medical University of Lublin  
Lublin, Poland

Edward Wolfe, DC  
Instructor  
Central Piedmont Community College  
Charlotte, North Carolina

Andrzej Zeglen  
Lincoln Memorial University-DeBusk College of  
Osteopathic Medicine  
Harrogate, Tennessee

In addition to reviewers, many people, some of them unknowingly, helped us by discussing parts of the manuscript and/or providing constructive criticism of the text and illustrations in the present and previous editions:

- Dr. Peter H. Abrahams, Professor of Clinical Anatomy, Warwick Medical School, United Kingdom
- Dr. Robert D. Acland, Professor of Surgery/Microsurgery, Division of Plastic and Reconstructive Surgery, University of Louisville, Louisville, Kentucky
- Dr. Edna Becker, Associate Professor of Medical Imaging, University of Toronto Faculty of Medicine, Toronto, Ontario
- Dr. Donald R. Cahill, Professor of Anatomy (retired; former Chair), Mayo Medical School; former Editor-in-Chief of Clinical Anatomy, Tucson, Arizona
- Dr. Joan Campbell, Assistant Professor of Medical Imaging, University of Toronto Faculty of Medicine, Toronto, Ontario
- Dr. Stephen W. Carmichael, Professor Emeritus, Mayo Medical School, Rochester, Minnesota
- Dr. Carmine D. Clemente, Professor of Anatomy and Cell Biology and Professor of Neurobiology, Emeritus, University of California Los Angeles School of Medicine, Los Angeles, California
- Dr. James D. Collins, Distinguished Professor of Radiological Sciences, University of California Los Angeles School of Medicine/Center for Health Sciences, Los Angeles, California
- Dr. Raymond F. Gasser, Emeritus Professor of Cell Biology and Anatomy and Adjunct Professor of Obstetrics and Gynecology, Louisiana State University School of Medicine, New Orleans, Louisiana
- Dr. Douglas J. Gould, Professor of Neuroscience and Vice Chair, Oakland University William Beaumont School of Medicine, Rochester, Michigan
- Dr. Daniel O. Graney, Professor of Biological Structure, University of Washington School of Medicine, Seattle, Washington
- Dr. David G. Greathouse, former Professor and Chair, Belmont University School of Physical Therapy, Nashville, Tennessee
- Dr. Masoom Haider, Associate Professor of Medical Imaging, University of Toronto Faculty of Medicine, Toronto, Ontario
- Dr. John S. Halle, Professor, Belmont University School of Physical Therapy, Nashville, Tennessee
- Dr. Jennifer L. Halpern, Associate Professor, Department of Orthopaedic Surgery and Rehabilitation, Vanderbilt University, Nashville, Tennessee
- Dr. Walter Kucharczyk, Professor, Department of Medical Imaging, Faculty of Medicine, University of Toronto, Toronto, Ontario
- Dr. Nirusha Lachman, Professor of Anatomy, Mayo Medical School, Rochester, Minnesota
- Dr. H. Wayne Lambert, Associate Professor, Department of Neurobiology and Anatomy, West Virginia University School of Medicine, Morgantown, West Virginia
- Dr. Lillian Nanney, Professor of Plastic Surgery, Vanderbilt University School of Medicine, Nashville, Tennessee
- Dr. Todd R. Olson, Professor of Anatomy and Structural Biology, Albert Einstein College of Medicine, Bronx, New York
- Dr. Wojciech Pawlina, Professor and Chair of Anatomy, Mayo Medical School, Rochester, Minnesota
- Dr. T. V. N. Persaud, Professor Emeritus of Human Anatomy and Cell Science, Faculties of Medicine and Dentistry, University of Manitoba, Winnipeg, Manitoba, Canada
- Dr. Cathleen C. Pettepher, Professor of Cancer Biology, Vanderbilt University School of Medicine, Nashville, Tennessee
- Dr. Thomas H. Quinn, Professor of Biomedical Sciences, Creighton University School of Medicine, Omaha, Nebraska
- Dr. George E. Salter, Professor Emeritus of Anatomy, Department of Cell Biology, University of Alabama, Birmingham, Alabama
- Dr. Tatsuo Sato, Professor and Head (retired), Second Department of Anatomy, Tokyo Medical and Dental University Faculty of Medicine, Tokyo
- Dr. Ryan Splittergerber, Assistant Professor, Department of Genetics, Cell Biology and Anatomy, University of Nebraska Medical Center, College of Medicine, Omaha, Nebraska
- Dr. Joel A. Vilensky, Professor of Anatomy, Indiana University School of Medicine, Indianapolis, Indiana
- Dr. Edward C. Weber, The Imaging Center, Fort Wayne, Indiana
- Dr. David G. Whitlock, Professor Emeritus of Anatomy, University of Colorado Medical School, Denver, Colorado

Art plays a major role in facilitating learning, especially in anatomy. We extend our sincere gratitude and appreciation for the skills, talents, and timely work of our medical illustrators for this edition. Wynne Auyeung and Natalie Intven from Imagineeringart.com and Jennifer Clements from Lippincott Williams & Wilkins did a superb job in revising all of the illustrations for *COA7* and this edition of *ECA* for a more consistent, vibrant art program. We also thank Kam Yu, who prepared the illustrations for the first edition. We continue to benefit from the extensive surface anatomy project photographed by E. Anne Raynor, Senior Photographer, Vanderbilt Medical Art Group, under the direction of authors Art Dalley and Anne Agur, with the support of Lippincott Williams & Wilkins.

We wish to thank Dr. Edward C. Weber and Dr. Joel A. Vilensky for their review of clinical material, contribution to the Clinical Box features, and Medical Imaging photos.

Our appreciation and thanks are extended to the editorial and production teams at Lippincott Williams & Wilkins who provided their expertise in the development of this edition: Crystal Taylor, Acquisitions Editor; Julie Montalbano, Product Manager; Lauren Pecarich, Product Manager; Jennifer Clements, Art Director; Joshua

Haffner, Editorial Assistant; and Mary Stermel, Production Coordinator. We also thank Harold Medina of Absolute Service, Inc. Finally, thanks to the Sales Division at LWW, which has played a key role in the success of this book.

Keith L. Moore  
Anne M.R. Agur  
Arthur F. Dalley II





# CONTENTS

Preface vii  
Acknowledgments ix  
Figure Credits xxi

## Introduction to Clinical Anatomy 1

Approaches to Studying Anatomy 2  
Anatomicomedical Terminology 3  
    Anatomical Position 3  
    Anatomical Planes 3  
    Terms of Relationship and Comparison 4  
    Terms of Laterality 4  
    Terms of Movement 4  
    Anatomical Variations 5  
Integumentary System 6  
Skeletal System 9  
    Bones 9  
    Joints 14  
Muscular System 17  
    Skeletal Muscle 17  
    Cardiac Striated Muscle 19  
    Smooth Muscle 20  
Cardiovascular System 21  
    Arteries 23  
    Veins 24  
    Capillaries 25  
Lymphoid System 25  
Nervous System 27  
    Central Nervous System 28  
    Peripheral Nervous System 30  
    Somatic Nervous System 31  
    Structure and Components of a Typical  
        Spinal Nerve 31  
    Autonomic Nervous System 33  
    Sympathetic Visceral Motor Innervation 34  
    Parasympathetic Visceral Motor Innervation 37  
    Visceral Afferent Sensation 39  
**Medical Imaging of Body Systems 39**  
    Conventional Radiography 39  
    Computerized Tomography 40  
    Ultrasonography 40  
    Magnetic Resonance Imaging 41  
    Positron Emission Tomography 41

## 1 Thorax 43

Thoracic Wall 44  
    Skeleton of Thoracic Wall 44  
    Thoracic Apertures 44  
    Joints of Thoracic Wall 49  
    Movements of Thoracic Wall 49  
    Breasts 52  
    Muscles of Thoracic Wall 56  
    Nerves of Thoracic Wall 58  
    Vasculature of Thoracic Wall 59  
**Surface Anatomy of Thoracic Wall 61**  
Thoracic Cavity and Viscera 64  
    Endothoracic Fascia 64  
    Pleurae and Lungs 64  
**Surface Anatomy of Pleurae and Lungs 67**  
    Mediastinum 76  
    Anterior Mediastinum 77  
    Middle Mediastinum 77  
    Heart and Great Vessels 81  
**Surface Anatomy of Heart 88**  
    Superior Mediastinum 98  
    Posterior Mediastinum 103  
**Medical Imaging of Thorax 109**

## 2 Abdomen 111

Abdominal Cavity 112  
Anterolateral Abdominal Wall 112  
    Fascia of Anterolateral Abdominal Wall 113  
    Muscles of Anterolateral Abdominal Wall 113  
    Internal Surface of Anterolateral Abdominal  
        Wall 115  
**Surface Anatomy of Anterolateral Abdominal  
Wall 119**  
    Nerves of Anterolateral Abdominal Wall 120  
    Vessels of Anterolateral Abdominal Wall 120  
    Inguinal Region 121  
Peritoneum and Peritoneal Cavity 130  
    Peritoneal Vessels and Nerves 131  
    Peritoneal Formations 131  
    Subdivisions of Peritoneal Cavity 132  
Abdominal Viscera 135  
    Esophagus 137  
    Stomach 137  
    Small Intestine 141

<b>Surface Anatomy of Stomach</b>	142
Large Intestine	148
Spleen	154
<b>Surface Anatomy of Spleen and Pancreas</b>	155
Pancreas	155
Liver	158
<b>Surface Anatomy of Liver</b>	160
Biliary Ducts and Gallbladder	163
Hepatic Portal Vein and Portosystemic Anastomoses	167
Kidneys, Ureters, and Suprarenal Glands	167
Summary of Innervation of Abdominal Viscera	172
<b>Surface Anatomy of Kidneys and Ureters</b>	173
Diaphragm	179
Diaphragmatic Apertures	180
Vasculature and Nerves of Diaphragm	182
Posterior Abdominal Wall	183
Fascia of Posterior Abdominal Wall	183
Muscles of Posterior Abdominal Wall	184
Nerves of Posterior Abdominal Wall	184
Vasculature of Posterior Abdominal Wall	186
Lymphatics of Posterior Abdominal Wall	187
<b>Medical Imaging of Abdomen</b>	190

### 3 Pelvis and Perineum 195

Pelvis	196
Pelvic Girdle	196
Joints and Ligaments of Pelvic Girdle	200
Peritoneum and Peritoneal Cavity of Pelvis	202
Walls and Floor of Pelvic Cavity	202
Pelvic Fascia	206
Pelvic Nerves	208
Pelvic Arteries and Veins	211
Lymph Nodes of Pelvis	214
Pelvic Viscera	214
Urinary Organs	214
Male Internal Genital Organs	224
Female Internal Genital Organs	227
Rectum	237
Perineum	241
Fascias and Pouches of Urogenital Triangle	244
Features of Anal Triangle	248
Male Perineum	252
Female Perineum	259
<b>Medical Imaging of Pelvis and Perineum</b>	262

### 4 Back 265

Vertebral Column	266
Curvatures of Vertebral Column	267
<b>Surface Anatomy of Curvatures of Vertebral Column</b>	267
Structure and Function of Vertebrae	268
Regional Characteristics of Vertebrae	269
<b>Surface Anatomy of Vertebral Column</b>	277
Joints of Vertebral Column	279
Movements of Vertebral Column	282
Vasculature of Vertebral Column	284
Innervation of Vertebral Column	285
Spinal Cord and Meninges	288
Structure of Spinal Nerves	288
Spinal Meninges and Cerebrospinal Fluid (CSF)	288
Vasculature of Spinal Cord and Spinal Nerve Roots	292
Muscles of Back	295
Extrinsic Back Muscles	295
Intrinsic Back Muscles	295
<b>Surface Anatomy of Back Muscles</b>	296
Suboccipital and Deep Neck Muscles	300
<b>Medical Imaging of Back</b>	306

### 5 Lower Limb 309

Bones of Lower Limb	311
Hip Bone	311
Femur	311
Patella	315
Tibia	315
Fibula	315
Tarsus, Metatarsus, and Phalanges	315
<b>Surface Anatomy of Lower Limb Bones</b>	320
Fascia, Vessels, and Cutaneous Nerves of Lower Limb	322
Subcutaneous Tissue and Fascia	322
Venous Drainage of Lower Limb	324
Lymphatic Drainage of Lower Limb	326
Cutaneous Innervation of Lower Limb	326
Thigh and Gluteal Regions	329
Anterior Thigh Muscles	329
Medial Thigh Muscles	330
Neurovascular Structures and Relationships in Anteromedial Thigh	331
Femoral Triangle and Adductor Canal	331
Femoral Nerve	335
Femoral Sheath	335
Femoral Artery	336
Femoral Vein	337
Obturator Artery and Nerve	337

Gluteal and Posterior Thigh Regions	337
Gluteal Muscles	337
Gluteal Bursae	340
Posterior Thigh Muscles	340
Nerves of Gluteal Region and Posterior Thigh	342
Vasculature of Gluteal and Posterior Thigh Regions	342
Popliteal Fossa	346
Fascia of Popliteal Fossa	346
Vessels in Popliteal Fossa	346
Nerves in Popliteal Fossa	346
Leg	348
Anterior Compartment of Leg	348
Lateral Compartment of Leg	351
Posterior Compartment of Leg	353
Foot	362
Deep Fascia of Foot	362
Muscles of Foot	363
Nerves of Foot	365
Arteries of Foot	365
Venous Drainage of Foot	367
Lymphatic Drainage of Foot	367
Walking: The Gait Cycle	367
Joints of Lower Limb	369
Hip Joint	369
Knee Joint	374
Tibiofibular Joints	379
Ankle Joint	385
Joints of Foot	389
Arches of Foot	391
<i>Medical Imaging of Lower Limb</i>	394

## 6 Upper Limb 397

Bones of Upper Limb	398
Clavicle	399
Scapula	399
Humerus	402
Ulna and Radius	402
Bones of Hand	403
<i>Surface Anatomy of Upper Limb Bones</i>	407
Superficial Structures of Upper Limb	409
Fascia of Upper Limb	409
Cutaneous Nerves of Upper Limb	411
Venous Drainage of Upper Limb	413
Lymphatic Drainage of Upper Limb	414
Anterior Axio-appendicular Muscles	414
Posterior Axio-appendicular and Scapulohumeral Muscles	415
Superficial Posterior Axio-appendicular Muscles	416
Deep Posterior Axio-appendicular Muscles	416
Scapulohumeral Muscles	419

## *Surface Anatomy of Pectoral and Scapular Regions (Anterior and Posterior Axio-appendicular and Scapulohumeral Muscles)* 420

Axilla	419
Axillary Artery and Vein	421
Axillary Lymph Nodes	424
Brachial Plexus	425
Arm	432
Muscles of Arm	432
Arteries and Veins of Arm	432
Nerves of Arm	435
Cubital Fossa	438
<i>Surface Anatomy of Arm and Cubital Fossa</i>	439
Forearm	438
Muscles of Forearm	438
Nerves of Forearm	447
Arteries and Veins of Forearm	449
Hand	452
Fascia of Palm	453
Muscles of Hand	453
Flexor Tendons of Extrinsic Muscles	456
Arteries and Veins of Hand	457
Nerves of Hand	458
<i>Surface Anatomy of Forearm and Hand</i>	462
Joints of Upper Limb	465
Sternoclavicular Joint	465
Acromioclavicular Joint	466
Glenohumeral Joint	466
Elbow Joint	472
Proximal Radio-ulnar Joint	473
Distal Radio-ulnar Joint	475
Joints of Hand	478
<i>Medical Imaging of Upper Limb</i>	482

## 7 Head 485

Cranium	486
Facial Aspect of Cranium	486
Lateral Aspect of Cranium	486
Occipital Aspect of Cranium	488
Superior Aspect of Cranium	488
External Surface of Cranial Base	488
Internal Surface of Cranial Base	492
Scalp	492
Cranial Meninges	493
Dura Mater	494
Arachnoid Mater and Pia Mater	499
Meningeal Spaces	500
Brain	501
Parts of Brain	501
Ventricular System of Brain	502
Vasculature of Brain	505



- Face 507
  - Muscles of Face 507
  - Nerves of Face 507
  - Superficial Vasculature of Face and Scalp 510
  - Parotid Gland 514
- Orbits 517
  - Eyelids and Lacrimal Apparatus 518
  - Eyeball 521
  - Extra-ocular Muscles of Orbit 528
  - Nerves of Orbit 532
  - Vasculature of Orbit 533
- Temporal Region 537
  - Temporal Fossa 537
  - Infratemporal Fossa 538
- Temporomandibular Joint 543
- Oral Region 545
  - Oral Cavity 545
  - Oral Vestibule 545
  - Teeth and Gingivae 546
  - Palate 548
  - Tongue 551
  - Salivary Glands 555
- Pterygopalatine Fossa 558
- Nose 561
  - External Nose 561
  - Nasal Cavities 561
  - Paranasal Sinuses 562
- Ear 566
  - External Ear 566
  - Middle Ear 568
  - Internal Ear 570
- Medical Imaging of Head** 576

## 8 Neck 581

- Fascia of Neck 582
  - Cervical Subcutaneous Tissue and Platysma 582
  - Deep Cervical Fascia 582
- Superficial Structures of Neck: Cervical Regions 585
  - Lateral Cervical Region 586
  - Anterior Cervical Region 592
- Surface Anatomy of Cervical Regions and Triangles of Neck** 598
- Deep Structures of Neck 599
  - Prevertebral Muscles 599
  - Root of Neck 600
- Viscera of Neck 604
  - Endocrine Layer of Cervical Viscera 604
  - Respiratory Layer of Cervical Viscera 608
- Surface Anatomy of Larynx** 609
  - Alimentary Layer of Cervical Viscera 616
- Lymphatics in Neck 622
- Medical Imaging of Neck** 624

## 9 Review of Cranial Nerves 627

- Overview of Cranial Nerves 628
- Olfactory Nerve (CN I) 634
- Optic Nerve (CN II) 636
- Oculomotor Nerve (CN III) 638
- Trochlear Nerve (CN IV) 640
- Abducent Nerve (CN VI) 641
- Trigeminal Nerve (CN V) 643
- Facial Nerve (CN VII) 644
  - Somatic (Branchial) Motor 644
  - Visceral (Parasympathetic) Motor 644
  - Somatic (General) Sensory 644
  - Special Sensory (Taste) 644
- Vestibulocochlear Nerve (CN VIII) 647
- Glossopharyngeal Nerve (CN IX) 648
  - Somatic (Branchial) Motor 648
  - Visceral (Parasympathetic) Motor 648
  - Somatic (General) Sensory 648
  - Special Sensory (Taste) 649
  - Visceral Sensory 649
- Vagus Nerve (CN X) 649
  - Somatic (Branchial) Motor 650
  - Visceral (Parasympathetic) Motor 650
  - Somatic (General) Sensory 650
  - Special Sensory (Taste) 653
  - Visceral Sensory 653
- Spinal Accessory Nerve (CN XI) 653
- Hypoglossal Nerve (CN XII) 654

## Clinical Boxes

### Introduction to Clinical Anatomy

- Skin Incisions and Wounds** 9
- Bone Dynamics** 10
- Accessory Bones** 13
- Assessment of Bone Age** 13
- Displacement and Separation of Epiphyses** 14
- Acascular Necrosis** 14
- Degenerative Joint Disease** 14
- Muscle Testing** 20
- Electromyography** 21
- Muscular Atrophy** 21
- Compensatory Hypertrophy and Myocardial Infarction** 21
- Anastomoses, Collateral Circulation, and Terminal (End) Arteries** 24
- Arteriosclerosis: Ischemia and Infarction** 24
- Varicose Veins** 25
- Lymphangitis, Lymphadenitis, and Lymphedema** 27
- Damage to Central Nervous System** 28
- Peripheral Nerve Degeneration** 31

## Chapter 1 Thorax

<i>Role of Costal Cartilages</i>	50
<i>Rib Fractures</i>	50
<i>Flail Chest</i>	50
<i>Supernumerary Ribs</i>	50
<i>Thoracotomy, Intercostal Space Incisions, and Rib Excision</i>	50
<i>Sternal Biopsies</i>	50
<i>Median Sternotomy</i>	50
<i>Thoracic Outlet Syndrome</i>	51
<i>Dislocation of Ribs</i>	51
<i>Paralysis of Diaphragm</i>	51
<i>Sternal Fractures</i>	51
<i>Breast Quadrants</i>	54
<i>Changes in Breasts</i>	54
<i>Supernumerary Breasts and Nipples</i>	54
<i>Carcinoma of Breast</i>	54
<i>Mammography</i>	55
<i>Surgical Incisions of Breast</i>	56
<i>Breast Cancer in Men</i>	56
<i>Herpes Zoster Infection</i>	61
<i>Dyspnea—Difficult Breathing</i>	61
<i>Intercostal Nerve Block</i>	61
<i>Pulmonary Collapse</i>	74
<i>Pneumothorax, Hydrothorax, Hemothorax, and Chylothorax</i>	74
<i>Pleuritis</i>	74
<i>Variation in Lobes of Lungs</i>	74
<i>Thoracentesis</i>	74
<i>Auscultation and Percussion of Lungs</i>	74
<i>Aspiration of Foreign Bodies</i>	75
<i>Lung Resections</i>	75
<i>Injury to Pleurae</i>	75
<i>Thoracoscopy</i>	75
<i>Pulmonary Embolism</i>	75
<i>Inhalation of Carbon Particles</i>	75
<i>Bronchogenic Carcinoma</i>	76
<i>Bronchoscopy</i>	76
<i>Surgical Significance of Transverse Pericardial Sinus</i>	80
<i>Pericarditis and Pericardial Effusion</i>	80
<i>Cardiac Tamponade</i>	80
<i>Levels of Viscera in Mediastinum</i>	80
<i>Percussion of Heart</i>	87
<i>Atrial and Ventricular Septal Defects</i>	87
<i>Thrombi</i>	87
<i>Valvular Heart Disease</i>	87
<i>Coronary Artery Disease or Coronary Heart Disease</i>	96
<i>Coronary Bypass Graft</i>	96
<i>Coronary Angioplasty</i>	97
<i>Variations of Coronary Arteries</i>	97
<i>Echocardiography</i>	97

<i>Cardiac Referred Pain</i>	97
<i>Injury to Conducting System of Heart</i>	97
<i>Laceration of Thoracic Duct</i>	107
<i>Collateral Venous Routes to Heart</i>	107
<i>Aneurysm of Ascending Aorta</i>	107
<i>Injury to Recurrent Laryngeal Nerves</i>	108
<i>Variations of Great Arteries</i>	108
<i>Coarctation of Aorta</i>	108
<i>Age Changes in Thymus</i>	108

## Chapter 2 Abdomen

<i>Clinical Significance of Fascia and Fascial Spaces of Abdominal Wall</i>	117
<i>Abdominal Surgical Incisions</i>	117
<i>Endoscopic Surgery</i>	118
<i>Incisional Hernia</i>	118
<i>Protuberance of Abdomen</i>	118
<i>Palpation of Anterolateral Abdominal Wall</i>	118
<i>Hydrocele and Hematocele</i>	127
<i>Vasectomy</i>	127
<i>Palpation of Superficial Inguinal Ring</i>	127
<i>Varicocele</i>	127
<i>Relocation of Testes and Ovaries</i>	128
<i>Inguinal Hernias</i>	129
<i>Testicular Cancer</i>	130
<i>Cremasteric Reflex</i>	130
<i>The Peritoneum and Surgical Procedures</i>	135
<i>Peritonitis and Ascites</i>	135
<i>Peritoneal Adhesions and Adhesiotomy</i>	135
<i>Abdominal Paracentesis</i>	135
<i>Functions of Greater Omentum</i>	135
<i>Spread of Pathological Fluids</i>	135
<i>Overview of Embryological Rotation of Midgut</i>	148
<i>Hiatal Hernia</i>	152
<i>Carcinoma of Stomach and Gastrectomy</i>	153
<i>Gastric Ulcers, Peptic Ulcers, Helicobacter pylori, and Vagotomy</i>	153
<i>Duodenal (Peptic) Ulcers</i>	153
<i>Ileal Diverticulum</i>	153
<i>Diverticulosis</i>	154
<i>Appendicitis</i>	154
<i>Appendectomy</i>	154
<i>Colitis, Colectomy, and Ileostomy</i>	154
<i>Colonoscopy</i>	154
<i>Rupture of Spleen and Splenomegaly</i>	158
<i>Rupture of Pancreas</i>	158
<i>Pancreatic Cancer</i>	158
<i>Subphrenic Abscesses</i>	160
<i>Liver Biopsy</i>	166
<i>Rupture of Liver</i>	166
<i>Cirrhosis of Liver</i>	166
<i>Hepatic Lobectomies and Segmentectomy</i>	166
<i>Gallstones</i>	166

- Cholecystectomy* 166  
*Portal Hypertension* 168  
*Perinephric Abscess* 174  
*Renal Transplantation* 174  
*Accessory Renal Vessels* 174  
*Renal and Ureteric Calculi* 174  
*Intraperitoneal Injection and Peritoneal Dialysis* 174  
*Congenital Anomalies of Kidneys and Ureters* 174  
*Visceral Referred Pain* 177  
*Section of a Phrenic Nerve* 182  
*Referred Pain from Diaphragm* 182  
*Rupture of Diaphragm and Herniation of Viscera* 182  
*Congenital Diaphragmatic Hernia* 182  
*Psoas Abscess* 189  
*Posterior Abdominal Pain* 189  
*Collateral Routes for Abdominopelvic Venous Blood* 189  
*Abdominal Aortic Aneurysm* 189
- Chapter 3 Pelvis and Perineum**  
*Sexual Differences in Bony Pelves* 200  
*Pelvic Fractures* 200  
*Relaxation of Pelvic Ligaments and Increased Joint Mobility during Pregnancy* 202  
*Injury to Pelvic Floor* 208  
*Injury to Pelvic Nerves* 209  
*Ureteric Calculi* 216  
*Suprapubic Cystostomy* 219  
*Rupture of Bladder* 219  
*Cystoscopy* 219  
*Sterilization of Males* 224  
*Prostatic Enlargement, Prostatic Cancer, and Prostatectomy* 226  
*Distention and Examination of Vagina* 229  
*Culdocentesis* 229  
*Hysterectomy* 234  
*Cervical Examination and Pap Smear* 235  
*Regional Anesthesia for Childbirth* 235  
*Manual Examination of Uterus* 235  
*Infections of Female Genital Tract* 236  
*Patency of Uterine Tubes* 236  
*Ligation of Uterine Tubes* 236  
*Laparoscopic Examination of Pelvic Viscera* 236  
*Ectopic Tubal Pregnancy* 236  
*Rectal Examination* 239  
*Resection of Rectum* 239  
*Disruption of Perineal Body* 244  
*Episiotomy* 244  
*Rupture of Urethra in Males and Extravasation of Urine* 247  
*Ischio-Anal Abscesses* 249  
*Hemorrhoids* 251  
*Urethral Catheterization* 252
- Impotence and Erectile Dysfunction* 257  
*Phimosis, Paraphimosis, and Circumcision* 257  
*Dilation of Female Urethra* 261  
*Inflammation of Greater Vestibular Glands* 261  
*Pudendal and Ilio-inguinal Nerve Blocks* 261
- Chapter 4 Back**  
*Abnormal Curvatures of Vertebral Column* 267  
*Laminectomy* 275  
*Fractures of Vertebrae* 275  
*Spina Bifida* 275  
*Dislocation of Cervical Vertebrae* 275  
*Lumbar Spinal Stenosis* 276  
*Reduced Blood Supply to Brainstem* 276  
*Herniation of Nucleus Pulposus* 286  
*Rupture of Transverse Ligament of Atlas* 286  
*Rupture of Alar Ligaments* 286  
*Aging of Vertebrae and Intervertebral Discs* 287  
*Injury and Disease of Zygapophysial Joints* 287  
*Vertebral Body Osteoporosis* 287  
*Back Pains* 287  
*Ischemia of Spinal Cord* 292  
*Alternative Circulation Pathways* 292  
*Lumbar Spinal Puncture* 294  
*Epidural Anesthesia (Blocks)* 294  
*Back Sprains and Strains* 304
- Chapter 5 Lower Limb**  
*Fractures of Hip Bone* 311  
*Femoral Fractures* 318  
*Coxa Vara and Coxa Valga* 318  
*Tibial and Fibular Fractures* 319  
*Bone Grafts* 319  
*Fractures Involving Epiphysial Plates* 319  
*Fractures of Foot Bones* 320  
*Abnormalities of Sensory Function* 328  
*Compartment Syndromes in Leg and Fasciotomy* 328  
*Saphenous Nerve Injury* 328  
*Varicose Veins, Thrombosis, and Thrombophlebitis* 328  
*Enlarged Inguinal Lymph Nodes* 329  
*Regional Nerve Blocks of Lower Limbs* 329  
*Hip and Thigh Contusions* 333  
*Patellar Tendon Reflex* 333  
*Paralysis of Quadriceps* 333  
*Chondromalacia Patellae* 333  
*Transplantation of Gracilis* 333  
*Groin Pull* 333  
*Femoral Hernia* 338  
*Replaced or Accessory Obturator Artery* 338  
*Femoral Pulse and Cannulation of Femoral Artery* 338  
*Cannulation of Femoral Vein* 338  
*Trochanteric and Ischial Bursitis* 344

- Injury to Superior Gluteal Nerve* 345  
*Hamstring Injuries* 345  
*Injury to Sciatic Nerve* 345  
*Intragluteal Injections* 345  
*Popliteal Pulse* 348  
*Popliteal Aneurysm* 348  
*Tibialis Anterior Strain (Shin Splints)* 352  
*Containment and Spread of Compartmental Infections in Leg* 352  
*Injury to Common Fibular Nerve and Footdrop* 352  
*Deep Fibular Nerve Entrapment* 353  
*Superficial Fibular Nerve Entrapment* 353  
*Palpation of Dorsalis Pedis Pulse* 353  
*Gastrocnemius Strain* 361  
*Posterior Tibial Pulse* 361  
*Injury to Tibial Nerve* 361  
*Absence of Plantarflexion* 361  
*Calcaneal Tendon Reflex* 361  
*Inflammation and Rupture of Calcaneal Tendon* 361  
*Calcaneal Bursitis* 361  
*Plantar Fasciitis* 369  
*Hemorrhaging Wounds of Sole of Foot* 369  
*Sural Nerve Grafts* 369  
*Plantar Reflex* 369  
*Contusion of Extensor Digitorum Brevis* 369  
*Medial Plantar Nerve Entrapment* 369  
*Fractures of Femoral Neck (Hip Fractures)* 374  
*Surgical Hip Replacement* 374  
*Dislocation of Hip Joint* 374  
*Genu Varum and Genu Valgum* 381  
*Patellofemoral Syndrome* 382  
*Patellar Dislocation* 382  
*Popliteal Cysts* 382  
*Knee Joint Injuries* 383  
*Arthroscopy of Knee Joint* 383  
*Knee Replacement* 383  
*Bursitis in Knee Region* 383  
*Tibial Nerve Entrapment* 388  
*Ankle Sprains* 388  
*Pott Fracture–Dislocation of Ankle* 388  
*Hallux Valgus* 393  
*Pes Planus (Flatfeet)* 393
- Chapter 6 Upper Limb**  
*Fracture of Clavicle* 404  
*Ossification of Clavicle* 405  
*Fracture of Scapula* 405  
*Fractures of Humerus* 405  
*Fractures of Ulna and Radius* 406  
*Fractures of Hand* 406  
*Paralysis of Serratus Anterior* 416  
*Venipuncture* 416  
*Injury to Axillary Nerve* 419
- Rotator Cuff Injuries and Supraspinatus* 419  
*Compression of Axillary Artery* 423  
*Arterial Anastomoses Around Scapula* 423  
*Injury to Axillary Vein* 424  
*Enlargement of Axillary Lymph Nodes* 425  
*Variations of Brachial Plexus* 430  
*Brachial Plexus Injuries* 430  
*Brachial Plexus Block* 431  
*Biceps Tendinitis* 436  
*Rupture of Tendon of Long Head of Biceps* 436  
*Bicipital Myotatic Reflex* 436  
*Injury to Musculocutaneous Nerve* 436  
*Injury to Radial Nerve* 437  
*Occlusion or Laceration of Brachial Artery* 437  
*Measuring Blood Pressure* 437  
*Compression of Brachial Artery* 437  
*Muscle Testing of Flexor Digitorum Superficialis and Flexor Digitorum Profundus* 451  
*Elbow Tendinitis or Lateral Epicondylitis* 451  
*Synovial Cyst of Wrist* 451  
*Mallet or Baseball Finger* 451  
*Dupuytren Contracture of Palmar Fascia* 459  
*Tenosynovitis* 460  
*Carpal Tunnel Syndrome* 460  
*Trauma to Median Nerve* 460  
*Ulnar Nerve Injury* 461  
*Radial Nerve Injury* 461  
*Laceration of Palmar Arches* 462  
*Palmar Wounds and Surgical Incisions* 462  
*Ischemia of Digits* 462  
*Rotator Cuff Injuries* 470  
*Dislocation of Acromioclavicular Joint* 470  
*Dislocation of Glenohumeral Joint* 471  
*Calcific Supraspinatus Tendinitis* 471  
*Adhesive Capsulitis of Glenohumeral Joint* 471  
*Bursitis of Elbow* 476  
*Avulsion of Medial Epicondyle* 476  
*Ulnar Collateral Ligament Reconstruction* 476  
*Dislocation of Elbow Joint* 476  
*Subluxation and Dislocation of Radial Head* 477  
*Wrist Fractures and Dislocations* 481
- Chapter 7 Head**  
*Fractures of Cranium* 488  
*Scalp Injuries and Infections* 493  
*Occlusion of Cerebral Veins and Dural Venous Sinuses* 497  
*Metastasis of Tumor Cells to Dural Sinuses* 497  
*Fractures of Cranial Base* 497  
*Dural Origin of Headaches* 499  
*Head Injuries and Intracranial Hemorrhage* 500  
*Cerebral Injuries* 503  
*Hydrocephalus* 503  
*Leakage of Cerebrospinal Fluid* 504



*Cisternal Puncture* 504  
*Strokes* 506  
*Transient Ischemic Attacks* 507  
*Facial Injuries* 507  
*Pulses of Arteries of Face* 512  
*Compression of Facial Artery* 512  
*Squamous Cell Carcinoma of Lip* 514  
*Trigeminal Neuralgia* 515  
*Infection of Parotid Gland* 516  
*Lesions of Trigeminal Nerve* 516  
*Bell Palsy* 516  
*Parotidectomy* 516  
*Fractures of Orbit* 518  
*Orbital Tumors* 518  
*Injury to Nerves Supplying Eyelids* 521  
*Inflammation of Palpebral Glands* 521  
*Ophthalmoscopy* 526  
*Detachment of Retina* 526  
*Papilledema* 527  
*Presbyopia and Cataracts* 527  
*Glaucoma* 527  
*Corneal Ulcers and Transplants* 527  
*Development of Retina* 527  
*Blockage of Central Retinal Artery* 536  
*Blockage of Central Retinal Vein* 536  
*Pupillary Light Reflex* 536  
*Corneal Reflex* 536  
*Paralysis of Extra-ocular Muscles/Palsies of Orbital Nerves* 536  
*Oculomotor Nerve Palsy* 536  
*Abducent Nerve Palsy* 536  
*Mandibular Nerve Block* 544  
*Inferior Alveolar Nerve Block* 544  
*Dislocation of Temporomandibular Joint* 544  
*Arthritis of Temporomandibular Joint* 545  
*Dental Caries, Pulpitis, and Toothache* 548  
*Gingivitis and Periodontitis* 548  
*Imaging of Salivary Glands* 557  
*Gag Reflex* 557  
*Paralysis of Genioglossus* 557  
*Injury to Hypoglossal Nerve* 557  
*Sublingual Absorption of Drugs* 557  
*Lingual Carcinoma* 557  
*Nasal Fractures* 565  
*Deviation of Nasal Septum* 565  
*Rhinitis* 565  
*Epistaxis* 565  
*Sinusitis* 565  
*Infection of Ethmoidal Cells* 565  
*Infection of Maxillary Sinuses* 565  
*Relationship of Teeth to Maxillary Sinus* 566  
*External Ear Injury* 574

*Otoscope Examination* 574  
*Acute Otitis Externa* 574  
*Otitis Media* 575  
*Perforation of Tympanic Membrane* 575

#### Chapter 8 Neck

*Spread of Infection in Neck* 584  
*Congenital Torticollis* 585  
*Nerve Blocks in Lateral Cervical Region* 591  
*Severance of Phrenic Nerve and Phrenic Nerve Block* 591  
*Subclavian Vein Puncture* 591  
*Prominence of External Jugular Vein* 591  
*Ligation of External Carotid Artery* 597  
*Surgical Dissection of Carotid Triangle* 597  
*Carotid Occlusion and Endarterectomy* 597  
*Carotid Pulse* 597  
*Internal Jugular Pulse* 597  
*Internal Jugular Vein Puncture* 597  
*Cervicothoracic Ganglion Block* 604  
*Lesion of Cervical Sympathetic Trunk* 604  
*Thyroidectomy* 607  
*Accessory Thyroid Tissue* 607  
*Injury to Laryngeal Nerves* 614  
*Fractures of Laryngeal Skeleton* 614  
*Aspiration of Foreign Bodies* 614  
*Tracheostomy* 615  
*Laryngoscopy* 615  
*Radical Neck Dissections* 623  
*Adenoiditis* 623  
*Foreign Bodies in Laryngopharynx* 623  
*Tonsillectomy* 623  
*Zones of Penetrating Trauma* 624

#### Chapter 9 Review of Cranial Nerves

*Anosmia—Loss of Smell* 635  
*Visual Field Defects* 637  
*Demyelinating Diseases and the Optic Nerve* 638  
*Ocular Palsies* 641  
*Injury to Trigeminal Nerve* 644  
*Injury to Facial Nerve* 644  
*Corneal Reflex* 646  
*Injuries of Vestibulocochlear Nerve* 648  
*Deafness* 648  
*Acoustic Neuroma* 648  
*Lesions of Glossopharyngeal Nerve* 650  
*Lesions of Vagus Nerve* 652  
*Injury to Spinal Accessory Nerve* 654  
*Injury to Hypoglossal Nerve* 655

Index 657

# FIGURE CREDITS

All sources are published by Lippincott Williams & Wilkins unless otherwise noted.

## INTRODUCTION

- Figure I.32** Courtesy of Dr. E.L. Lansdown, Professor of Medical Imaging, University of Toronto, Ontario, Canada.
- Figure I.33A–C** Wicke L. *Atlas of Radiologic Anatomy*. 6th English ed. Taylor AN, trans-ed. Baltimore: Williams & Wilkins; 1998. [Wicke L. *Roentgen-Anatomie Normalbefunde*. 5th ed. Munich: Urban and Schwarzenberg; 1995.]
- Figures I.34–I.35A** Wicke L. *Atlas of Radiologic Anatomy*. 6th English ed. Taylor AN, trans-ed. Baltimore: Williams & Wilkins; 1998. [Wicke L. *Roentgen-Anatomie Normalbefunde*. 5th ed. Munich: Urban and Schwarzenberg; 1995.]
- Figure I.35B** Dean D, Herbener TE. *Cross-Sectional Human Anatomy*. 2000.
- Figure I.36** Posner MI, Raichle M. *Images of Mind*. New York: Scientific American Library; 1994.
- Figure BI.1A&B** Based on Willis MC. *Medical Terminology, The Language of Health Care*. Baltimore: Lippincott Williams & Wilkins; 1995.
- Figure BI.2** Reprinted with permission from *Roche Lexikon Medizin*. 4th ed. Munich: Urban & Schwarzenberg; 1998.
- ## CHAPTER 1
- Figure 1.20A** Courtesy of DE Saunders, University of Toronto, Ontario, Canada.
- Figure 1.27A** Courtesy of Dr. E.L. Lansdown, Professor of Medical Imaging, University of Toronto, Ontario, Canada.
- Figure 1.50B&D** Courtesy of I. Morrow, University of Manitoba, Canada.
- Figure 1.50C** Courtesy of I. Verschuur, Joint Department of Medical Imaging,

- UHN/Mount Sinai Hospital, Toronto, Canada.
- Figure B1.4A&B** Based on Bickley LS, Szilagyi PG. *Bates' Guide to Physical Examination*. 10th ed. 2009. Table 10-2, p. 414.
- Figure B1.10** *Stedman's Medical Dictionary*. 27th ed. 2000. (artist: Neil O. Hardy, Westport, CT); photographs of bronchus, carina, and trachea from Feinsilver SH, Fein A. *Textbook of Bronchoscopy*. Baltimore: Williams & Wilkins; 1995; photograph of bronchoscopy procedure—courtesy of Temple University Hospital, Philadelphia.
- Figure B1.13** Based on *Stedman's Medical Dictionary*. 27th ed. 2000. (artist: Neil O. Hardy, Westport, CT).
- Figure B1.15** Based on figures provided by the Anatomical Chart Company.
- Figure B1.17** Based on *Stedman's Medical Dictionary*. 27th ed. 2000. (artist: Neil O. Hardy, Westport, CT).
- Figure SA1.2C** Based on figures provided by the Anatomical Chart Company.

## CHAPTER 2

- Figure 2.2** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 5.10B, 5.11B, and 5.11C, pp. 222–223
- Figure 2.4B–E** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plate 7-3, p. 270.
- Figure 2.19A** Based on *Stedman's Medical Dictionary*. 27th ed. 2000. (artist: Neil O. Hardy, Westport, CT).
- Figure 2.22C** Courtesy of Dr. E.L. Lansdown, Professor of Medical Imaging, University of Toronto, Ontario, Canada.
- Figure 2.28A** Based on *Stedman's Medical Dictionary*. 27th ed. 2000. (artist: Neil O. Hardy, Westport, CT).
- Figure 2.28C&D** Based on Sauerland EK. *Grant's Dissector*. 12th ed. 1999.
- Figure 2.38B&C** Reprinted with permission from Karaliotas C, Broelsch C, Habib N, et al. *Liver and Biliary Tract Surgery: Embryological Anatomy to 3D-Imaging and Transplant Innovations*. Vienna: Springer; 2007. Fig. 2.13, p. 28.
- Figure 2.40A&C** Courtesy of Dr. GB Haber, University of Toronto, Ontario, Canada.
- Figure 2.50A** This figure provided by Ed Weber & Joel Vilensky.
- Figure 2.56B** Based on Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008. Fig. 4-64, p. 171.
- Figure 2.67A–F** Courtesy of MA Haider, University of Toronto, Ontario, Canada.
- Figure 2.68A–C parts II**. Courtesy of Tom White, Department of Radiology, The Health Sciences Center, University of Tennessee, Memphis, Tennessee.
- Figure 2.69A–F** Courtesy of AM Arenson, University of Toronto, Ontario, Canada.
- Figure 2.70A** Courtesy of M. Asch, University of Toronto, Ontario, Canada.
- Figure 2.70B** Dean D, Herbener TE. *Cross-Sectional Human Anatomy*. 2000.
- Figure 2.70C** Courtesy of Dr. CS Ho, University of Toronto, Ontario, Canada.
- Figure B2.5** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 5.11B&C, p. 223.
- Figure B2.8** Brant WE, Helms CA. *Fundamentals of Diagnostic Radiology*. 2nd ed. 1999.
- Figure B2.9 inset** *Stedman's Medical Dictionary*. 28th ed. 2005.
- Figure B2.10** Bickley LS. *Bates' Guide to Physical Examination*. 10th ed. 2008, p. 429.
- Figure B2.11** Reprinted with permission from Moore KL, Persaud TVN. *The Developing Human*. 8th ed. Philadelphia: Saunders (Elsevier); 2008, Fig. 8.12C; courtesy of Dr. Prem S. Sahni, formerly of Department of Radiology, Children's Hospital, Winnipeg, Manitoba, Canada.

- Figure B2.12B** Based on Eckert P, et al. *Fibrinklebung, Indikation und Anwendung*. München: Urban & Schwarzenberg; 1986.
- Figure SA2.2B** Based on Basmajian JV, Slonecker CE. *Grant's Method of Anatomy*. 11th ed. Baltimore: Williams & Wilkins; 1989. Fig. 12.30, p. 150
- Figure SA2.3C** *Stedman's Medical Dictionary*. 27th ed. 2000. (artist: Neil O. Hardy, Westport, CT).
- Figure SA2.4** Based on Bickley LS, Szilagyi PG. *Bates' Guide to Physical Examination*. 10th ed. 2009, p. 440.

### CHAPTER 3

- Figure 3.8E** Based on DeLancey JO. Structure support of the urethra as it relates to stress urinary incontinence: the hammock hypothesis. *Am J Obstet Gynecol*. 1994;170:1713–1720.
- Figure 3.20B** Modified from Tank PW. *Grant's Dissector*. 13th ed. 2005, Fig. 5.21, p. 117.
- Figure 3.27A Right:** Based on Agur AMR, Dalley AF. *Grant's Atlas of Anatomy*. 12th ed. 2009, Fig. 3.21A, p. 217; **Left:** Based on Dauber W. *Pocket Atlas of Human Anatomy*. 5th rev ed. New York: Thieme; 2007, p. 195.
- Figure 3.36B** Courtesy of AM Arenson, University of Toronto, Ontario, Canada.
- Figure 3.42B** Based on Clemente CD. *Anatomy: A Regional Atlas of the Human Body*. 5th ed. 2006, Fig. 272.1.
- Figure 3.56A–E** Courtesy of MA Heider, University of Toronto, Ontario, Canada.
- Figure 3.58A** Beckmann CR et al. *Obstetrics and Gynecology*. 5th ed. 2006.
- Figure 3.58D** Daffner RH. *Clinical Radiology: The Essentials*. 2nd ed. 1998.
- Figure 3.58E** Erkonen WE, Smith WL. *Radiology 101: The Basics and Fundamentals of Imaging*. 3rd ed. 2009.
- Figure 3.58F** Daffner RH. *Clinical Radiology: The Essentials*. 2nd ed. 1998.
- Figure B3.2** Hartwig W. *Fundamental Anatomy*. 2007, p. 176.
- Figure B3.4A** Based on *Stedman's Medical Dictionary*. 27th ed. 2000.

- Figure B3.6** Based on *Stedman's Medical Dictionary*. 27th ed. 2000.
- Figure B3.7** Based on Tank PW, Gest TR. *Lippincott Williams and Wilkins Atlas of Anatomy*. 2008, plate 6.19A, p. 276.
- Figure B3.8** Based on Fuller J, Schaller-Ayers J. *A Nursing Approach*. 2nd ed. 1994, Fig. B3.11 (artist: Larry Ward, Salt Lake City, UT).
- Figure B3.9** Based on *Stedman's Medical Dictionary*. 27th ed. 2000.
- Figure B3.10A** Based on *Stedman's Medical Dictionary*. 27th ed. 2000.
- Figure B3.10B** With permission from Bristow RE, Johns Hopkins School of Medicine, Baltimore, MD.

### CHAPTER 4

- Figure 4.1C** Based on Olson TR. *Student Atlas of Anatomy*. 1996.
- Figure 4.3C** Courtesy of Dr. J. Heslin, University of Toronto, Ontario, Canada.
- Figure 4.4C** Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.
- Figure 4.4E** Courtesy of Dr. D. Armstrong, University of Toronto, Ontario, Canada.
- Figure 4.5D** Becker RF et al. *Anatomical Basis of Medical Practice*. Baltimore: Williams & Wilkins; 1974.
- Figure 4.6C&E** Courtesy of Dr. J. Heslin, University of Toronto, Ontario, Canada.
- Figure 4.6D** Becker RF et al. *Anatomical Basis of Medical Practice*. Baltimore: Williams & Wilkins; 1974.
- Figure 4.22B–E** Based on Olson TR. *Student Atlas of Anatomy*. 1996.
- Figure 4.26B&C** Wicke L. *Atlas of Radiologic Anatomy*. 6th English ed. Taylor AN, trans-ed. Baltimore: Williams & Wilkins; 1998. [Wicke L. *Roentgen-Anatomie Normalbefunde*. 5th ed. Munich: Urban and Schwarzenberg; 1995.]
- Figure 4.27A&B** Courtesy of the Visible Human Project, National Library of Medicine, Visible Man 1715.
- Figure 4.27C** Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.
- Figure 4.27D** Courtesy of Dr. D. Armstrong, University of Toronto, Ontario, Canada.

- Figure B4.3** Van de Graaff K. *Human Anatomy*. 4th ed. Dubuque, IA: WC Brown; 1995, p. 163.
- Figure B4.4** Clark CR. *The Cervical Spine*. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 1998.
- Figure B4.7** Median MRI ©LUHS2008. Loyola University Health System, Maywood, IL; transverse MRI—Choi SJ et al. The use of MRI to predict the clinical outcome of non-surgical treatment for lumbar I-V disc herniation. *Korean J Radiol*. 2007;8:156–163:5a.
- Figure SA4.1–SA4.3** LWW Surface Anatomy Photo Collection.

### CHAPTER 5

- Figure 5.12B&C** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plate 9.2.
- Figure 5.12D** Based on Melloni JL. *Melloni's Illustrated Review of Human Anatomy: By Structures—Arteries, Bones, Muscles, Nerves, Veins*. 1988.
- Figure 5.13B–G** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Figs. 9.24–9.28, pp. 352–356.
- Figure 5.19C–F** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Figs. 8.16–8.18 & plate 9.5, pp. 309–311, 322.
- Figure 5.22F–H** Based on Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Figs. 9.12–9.14, pp. 342–344.
- Figure 5.27D–F** Based on Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Figs. 10.10, 10.14, & 10.16, pp. 378, 380, & 382.
- Figure 5.29B&C** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plate 10.3, p. 364.
- Figure 5.30B–G** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plate 10.4, Figs. 10.22, 10.29, and 10.30, pp. 388, 393–394.
- Figure 5.39** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Fig. 10.41, p. 403



**Figure 5.40C–G** Based on Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plates 10.5 & 10.6, pp. 366–367.

**Figure 5.43** Based on Rose J, Gamble JG. *Human Walking*. 2nd ed. Baltimore: Williams & Wilkins; 1994.

**Figure 5.44A** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plate 9.1, p. 328.

**Figure 5.44B** Courtesy of Dr. E. Becker, University of Toronto, Ontario, Canada.

**Figure 5.45C** Based on Kapandji, IA. *The Physiology of the Joints. Vol. 2: Lower Limb*. 5th ed. Edinburgh, UK: Churchill Livingstone; 1987.

**Figure 5.48B&D** Courtesy of Dr. P. Bobechko, University of Toronto, Ontario, Canada.

**Figure 5.49B** Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.

**Figure 5.51D** Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.

**Figure 5.55A** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plate 10.1, p. 371.

**Figure 5.55B&C** Courtesy Dr. E. Becker, University of Toronto, Ontario, Canada.

**Figure 5.57A** Courtesy of Dr. W. Kucharczyk, University of Toronto, Ontario, Canada.

**Figure 5.59** Based on Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plate 10.1, p. 362.

**Figure 5.61C&D** Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.

**Figure 5.62D–F** Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.

**Figure B5.3B** Yochum TR, Rowe LJ. *Essentials of Skeletal Radiology*. 3rd ed. 2005.

**Figure B5.4** ©eMedicine.com, 2008.

**Figure B5.6A** Reprinted with permission from *Roche Lexikon Medizin*. 4th ed. Munich: Urban & Schwazernberg; 1998.

**Figure B5.6B–D** *Stedman's Medical Dictionary*. 28th ed. 2005. (artist: Neil O. Hardy, Westport, CT), p. 2090.

**Figure B5.14A** Willis MC. *Medical Terminology: A Programmed Learning Approach to the Language of Health Care*. Baltimore: Lippincott Williams & Wilkins; 2002.

**Figure B5.14B** Daffner RH. *Clinical Radiology: The Essentials*. 2nd ed. Baltimore: Williams & Wilkins, 1998.

**Figure B5.16A–C** Modified from Palastanga NP, Field DG, Soames R. *Anatomy and Human Movement*. 4th ed. Oxford, UK: Butterworth-Heinemann; 2002.

**Figure B5.16D&E** *Stedman's Medical Dictionary*. 27th ed. 2000.

## CHAPTER 6

**Figure 6.9** Courtesy Dr. E. Becker, University of Toronto, Ontario, Canada.

**Figure 6.13A** Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 2.53, p. 82.

**Figure 6.14B–E** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Figs. 4.1, 4.4, 4.9, 4.49, pp. 129, 131, 135, 162.

**Figure 6.17D** Based on Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Fig. 4.31, p. 149.

**Figure 6.26B** Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, plates 5.3, 5.4, Fig. 5.10, pp. 184–185, 199.

**Figure 6.27D** Based on Hoppenfeld S, de Boer P. *Surgical Exposures in Orthopaedics*. 3rd ed. 2003, Fig. 2.27, p. 89.

**Figure 6.52C** Modified from Hamil J, Knutzen KM. *Biomechanical Basis of Human Motion*. 2006, Fig. 5.8, p. 153.

**Figure 6.54A** Courtesy of Dr. E. Lansdown, University of Toronto, Ontario, Canada.

**Figure 6.55A&B** Courtesy of Dr. E. Becker, University of Toronto, Ontario, Canada.

**Figure 6.58C** Courtesy of Dr. J. Heslin, University of Toronto, Ontario, Canada.

**Figure 6.61A–C** Dean D, Herbener TE. *Cross-sectional Human Anatomy*. 2000, plates 7.2, 7.5, 7.8, pp. 134, 135, 140, 141, 146, 147.

**Figure 6.62A** Courtesy of Dr. W. Kucharczyk, University of Toronto, Ontario, Canada.

**Figure 6.62B&C** Lee JKT, Sagel SS, Stanley, RJ, Heiken, JP. *Computed Body Tomography with MRI Correlation*. Baltimore: Lippincott Williams & Wilkins; 2006, Fig. 22.13A&C, p. 1491.

**Figure B6.2** Hoppenfeld S, de Boer P. *Surgical Exposures in Orthopaedics*. 3rd ed. 2003, Fig. 2.27, p. 89.

**Figure B6.5** Rowland LP. *Merritt's Textbook of Neurology*. 9th ed. Baltimore: Williams & Wilkins; 1995.

**Figure B6.7** Anderson MK, Hall SJ, Martin M. *Foundations of Athletic Training*. 3rd ed. 1995.

**Figure B6.8** Bickley LS. *Bates' Guide to Physical Examination*. 10th ed. 2008, p. 697.

**Figure B6.19** <http://www.xray200.co.uk>

## CHAPTER 7

**Figure 7.8B** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.60B, p. 365.

**Figure 7.15A&B** Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.29, p. 324.

**Figure 7.19** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.73, p. 368.

**Figure 7.20** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.74, p. 369.

**Figure 7.24E** Courtesy of Dr. W. Kucharczyk, University of Toronto, Ontario, Canada.

**Figure 7.25A** Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.58, p. 353.

**Figure 7.28A** Based on Melloni JL. *Melloni's Illustrated Review of Human Anatomy: By Structures—Arteries, Bones, Muscles, Nerves, Veins*. 1988, p. 149.

**Figure 7.28B** Based on Van de Graaff K. *Human Anatomy*. 4th ed. Dubuque, IA: WC Brown; 1995, Fig. 15.18, p. 419.

**Figure 7.29** Welch Allyn, Inc., Skaneateles Falls, NY.



- Figure 7.30** Based on Van de Graaff K. *Human Anatomy*. 4th ed. Dubuque, IA: WC Brown; 1995, Fig. 15.17.
- Figure 7.33A** Based on Melloni JL. *Melloni's Illustrated Review of Human Anatomy: By Structures—Arteries, Bones, Muscles, Nerves, Veins*. 1988, p. 143.
- Figure 7.33B** Based on Melloni JL. *Melloni's Illustrated Review of Human Anatomy: By Structures—Arteries, Bones, Muscles, Nerves, Veins*. 1988, p. 141.
- Figure 7.34A–D** Based on Girard L. *Anatomy of the Human Eye. II. The Extra-ocular Muscles*. Houston, TX: Teaching Films, Inc.
- Figure 7.37A** Based on Melloni JL. *Melloni's Illustrated Review of Human Anatomy: By Structures—Arteries, Bones, Muscles, Nerves, Veins*. 1988, p. 189.
- Figure 7.41A–C** Based on Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Figs. 3.15, 3.16, & 3.19, pp. 82, 83, 86.
- Figure 7.46D&E** Langland OE, Langlais RP, Preece JW. *Principles of Dental Imaging*. 2002, Fig. 11.32A&B, p. 278.
- Figure 7.51A** Courtesy of Dr. M. J. Phatoah, University of Toronto, Ontario, Canada.
- Figure 7.57** Courtesy of Dr. B. Liebgott, University of Toronto, Ontario, Canada.
- Figure 7.58A** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.40A, p. 335.
- Figure 7.58C** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.38C, p. 333.
- Figure 7.62B** Based on Paff GH. *Anatomy of the Head & Neck*. Philadelphia: WB Saunders Co. 1973, Figs. 238–240, pp. 142–143.
- Figure 7.64A&B** Based on Paff GH. *Anatomy of the Head & Neck*. Philadelphia: WB Saunders Co. 1973, Figs. 238–240, pp. 142–143.
- Figure 7.64D&E** Based on Hall-Craggs ECB. *Anatomy as the Basis of Clinical Medicine*. 2nd ed. 1990, Fig. 9.100, p. 536.
- Figure 7.68B** Courtesy of Dr. E. Becker, University of Toronto, Ontario, Canada.
- Figure 7.68C** Courtesy of Dr. D. Armstrong, University of Toronto, Ontario, Canada.
- Figure 7.70A&B** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.66B&C.
- Figure 7.79** Seeley RR, Stephens TR, Tate P. *Anatomy & Physiology*. 6th ed. New York: McGraw-Hill; 2003, Fig. 15.28, p. 532.
- Figure 7.80A** Courtesy of Dr. E. Becker, University of Toronto, Ontario, Canada.
- Figure 7.80B&C** Courtesy of Dr. D. Armstrong, University of Toronto, Ontario, Canada.
- Figure 7.81A** Courtesy of Dr. W. Kucharczyk, University of Toronto, Ontario, Canada.
- Figure 7.81B** Courtesy of Dr. D. Armstrong, University of Toronto, Ontario, Canada.
- Figure 7.81C–F** Photos courtesy of the Visible Human Project, National Library of Medicine, Visible Man 1107 & 1168.
- Figure B7.3** ©Photographer/Visuals Unlimited, Hollis, New Hampshire.
- Figure B7.6** Skin Cancer Foundation.
- Figure B7.7** Photo courtesy of Welch Allyn, Inc., Skaneateles Falls, NY.
- Figure B7.8** Cohen BJ. *Medical Terminology*. 4th ed. 2003.
- Figure B7.9** Mann IC. *The Development of the Human Eye*. New York: Grune & Stratton; 1974.
- Figure B7.13** Hall-Craggs ECB. *Anatomy as the Basis of Clinical Medicine*. 3rd ed. 1995.
- Figure B7.14** Bechara Y, Ghorayeb MD, Houston, TX.

## CHAPTER 8

**Figure 8.2** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.10A&B, p. 305.

**Figure 8.4A** Based on Clay JH, Pounds DM. *Basic Clinical Massage Therapy: Integrating Anatomy and Treatment*. 2nd ed. 2008, Fig. 3.28, p. 94.

**Figure 8.16B** Courtesy of Dr. D. Salonen, University of Toronto, Ontario, Canada.

**Figure 8.22A** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.10, p. 305.

**Figure 8.23A** Courtesy of Dr. B. Liebgott, University of Toronto, Ontario, Canada.

**Figure 8.24B** Based on Tank PW, Gest TR. *Lippincott Williams & Wilkins Atlas of Anatomy*. 2008, plate 7.21, p. 316.

**Figure 8.27** Courtesy of Dr. J. Heslin, University of Toronto, Ontario, Canada

**Figure 8.28A** Courtesy of Dr. M. Keller, University of Toronto, Ontario, Canada.

**Figure 8.28B** Courtesy of Dr. Walter Kucharczyk, University of Toronto, Ontario, Canada.

**Figure 8.28C** Courtesy of I. Veschuur, UHN/ MSH, Toronto, Ontario, Canada.

**Figure 8.29** Siemens Medical Solutions, USA.

**Figure B8.1** Based on Rowland LP. *Merritt's Textbook of Neurology*. 9th ed. 1995.

**Figure B8.5** Klima G. *Schilddrüsen-Sonographie*. München: Urban & Schwarzenberg; 1989.

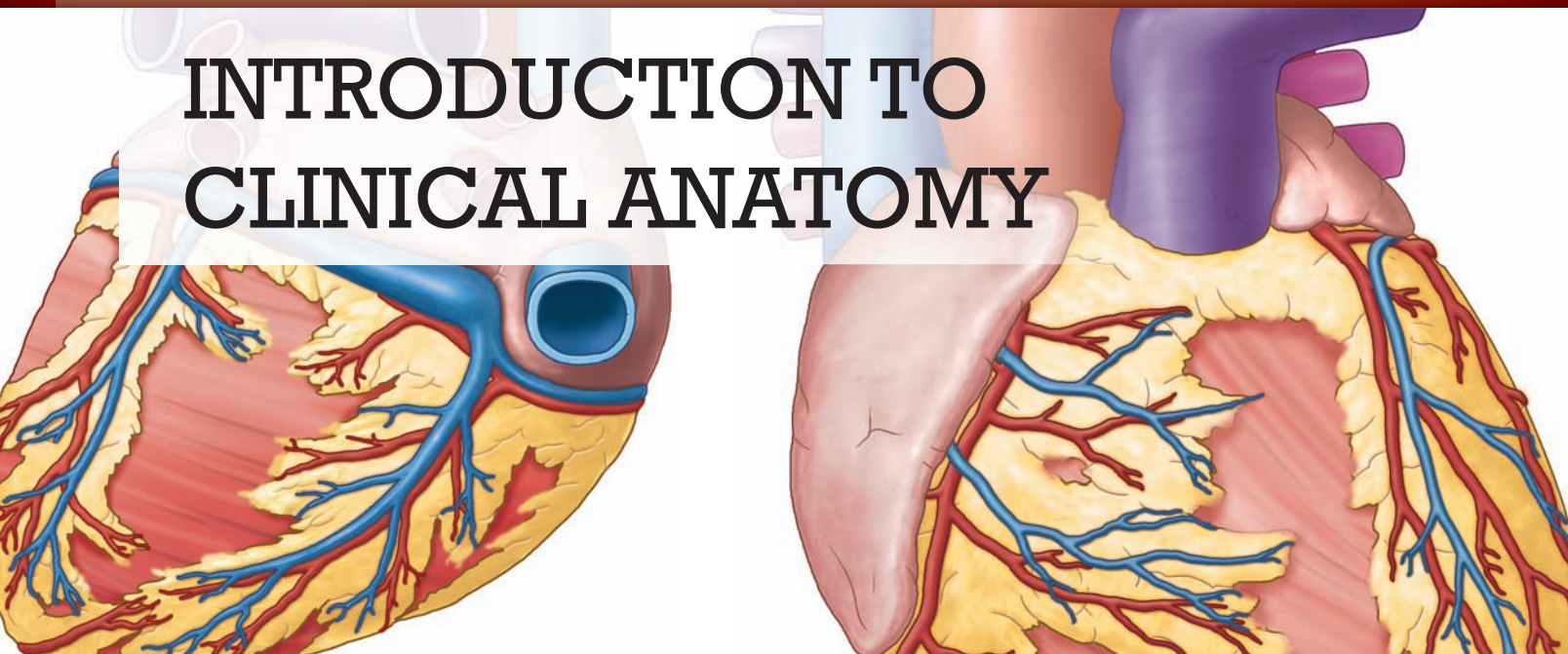
**Figure B8.6** Rohen JW, et al. *Color Atlas of Anatomy: A Photographic Study of the Human Body*. 5th ed. 2003.

## CHAPTER 9

**Figure 9.9A** Based on Melloni, JL. *Melloni's Illustrated Review of Human Anatomy: By Structures—Arteries, Bones, Muscles, Nerves, Veins*. 1988.

Note: Credits for figures based on illustrations from *Grant's Atlas of Anatomy and Clinically Oriented Anatomy* are available at <http://thepoint.lww.com>.

# INTRODUCTION TO CLINICAL ANATOMY



## APPROACHES TO STUDYING ANATOMY 2

### ANATOMICOMEDICAL TERMINOLOGY 3

Anatomical Position 3

Anatomical Planes 3

Terms of Relationship and  
Comparison 4

Terms of Laterality 4

Terms of Movement 4

Anatomical Variations 5

## INTEGUMENTARY SYSTEM 6

## SKELETAL SYSTEM 9

Bones 9

Joints 14

## MUSCULAR SYSTEM 17

Skeletal Muscle 17

Cardiac Striated Muscle 19

Smooth Muscle 20

## CARDIOVASCULAR SYSTEM 21

Arteries 23

Veins 24

Capillaries 25

## LYMPHOID SYSTEM 25

## NERVOUS SYSTEM 27

Central Nervous System 28

Peripheral Nervous System 30

Somatic Nervous System 31

Structure and Components of a Typical  
Spinal Nerve 31

Autonomic Nervous System 33

Sympathetic Visceral Motor  
Innervation 34

Parasympathetic Visceral Motor  
Innervation 37

Visceral Afferent Sensation 39

## MEDICAL IMAGING OF BODY SYSTEMS 39



Anatomical variations



Life cycle



Trauma



Diagnostic procedures



Surgical procedures



Pathology

*Essential Clinical Anatomy* relates the structure and function of the body to what is commonly required in the general practice of medicine, dentistry, and the allied health sciences. Because the number of details in anatomy overwhelms many beginning students, *Essential Clinical Anatomy* simplifies, correlates, and integrates the information so that it is easier to understand. The *clinical correlation boxes* (blue boxes) and *clinical case studies* (<http://thePoint.lww.com>) illustrate the clinical applications of anatomy. The *surface anatomy boxes* (orange boxes) provide an understanding of what lies under the skin, and the *medical imaging techniques* (green boxes), included throughout and at the end of each chapter, illustrate how anatomy is visualized clinically.

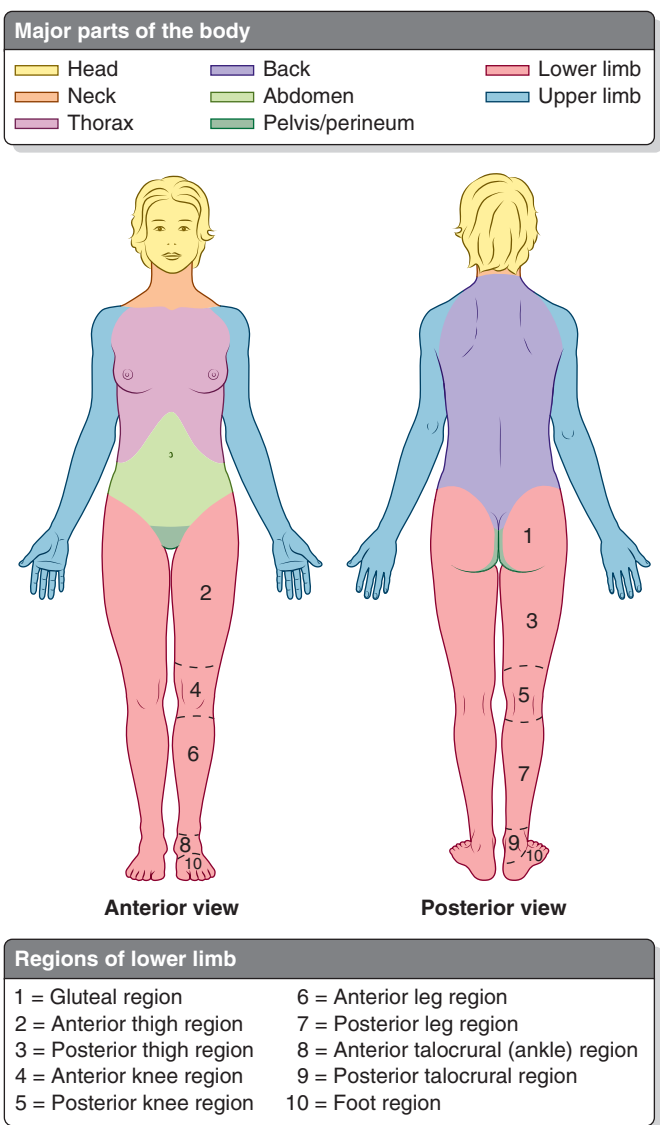
## APPROACHES TO STUDYING ANATOMY

There are three main approaches to studying human gross anatomy: regional, systemic, and clinical (applied). In this introductory chapter, the systemic approach is used; in subsequent chapters, the clinical and regional approaches are used.

**Regional anatomy** is based on the organization of the body into parts: head, neck, trunk (further subdivided into thorax, abdomen, pelvis/perineum, and back), and paired upper and lower limbs. Emphasis is placed on the relationships of various systemic structures (e.g., muscles, nerves, and arteries) within the region (Fig. I.1). Each region is not an isolated part and must be put into the context of adjacent regions and of the body as a whole. Surface anatomy is an essential part of the regional approach, providing a knowledge of what structures are visible and/or palpable (perceptible to touch) in the living body at rest and in action. The physical examination of patients is the clinical extension of surface anatomy. In people with stab wounds, for example, the healthcare worker must be able to visualize the deep structures that might be injured.

**Systemic anatomy** is an approach to anatomical study organized by *organ systems* that work together to carry out complex functions. None of the organ systems functions in isolation. For example, much of the skeletal, articular, and muscular systems constitute the *locomotor system*. And although the structures directly responsible for locomotion are the muscles, bones, joints, and ligaments, other systems are involved as well. The arteries and veins of the circulatory system supply oxygen to them and remove waste from them, and the nerves of the nervous system stimulate them to act. Brief descriptions of the systems of the body and their fields of study (in parentheses) follow:

- **Integumentary system** (dermatology): consists of the skin (integument) and its appendages, such as the hair and



**FIGURE I.1.** Anatomical position and regions of body.

nails. The skin, an extensive sensory organ, forms a protective covering for the body.

- **Skeletal system** (osteology, orthopedics): consists of bones and cartilage. It provides support for the body and protects vital organs. The muscular system acts on the skeletal system to produce movements.
- **Articular system** (arthrology): consists of joints and their associated ligaments. It connects the bony parts of the skeletal system and provides the sites at which movements occur.
- **Muscular system** (myology): consists of muscles that act (contract) to move or position parts of the body (e.g., the bones that articulate at joints)
- **Nervous system** (neurology): consists of the *central nervous system* (brain and spinal cord) and the *peripheral*



*nervous system* (nerves and ganglia, together with their motor and sensory endings). The nervous system controls and coordinates the functions of the organ systems.

- **Circulatory system** (angiology): consists of the cardiovascular and lymphatic systems, which function in parallel to distribute fluids within the body
  - **Cardiovascular system** (cardiology): consists of the heart and blood vessels that propel and conduct blood through the body
  - **Lymphoid system**: consists of a network of lymphatic vessels that withdraws excess tissue fluid (lymph) from the body's interstitial (intercellular) fluid compartment, filters it through lymph nodes, and returns it to the bloodstream
- **Digestive or alimentary system** (gastroenterology): consists of the organs and glands associated with the ingestion, mastication (chewing), deglutition (swallowing), digestion, and absorption of food and the elimination of feces (solid wastes) after the nutrients have been absorbed
- **Respiratory system** (pulmonology): consists of the air passages and lungs that supply oxygen and eliminate carbon dioxide. The control of airflow through the system produces tone, which is further modified into speech.
- **Urinary system** (urology): consists of the kidneys, ureters, urinary bladder, and urethra, which filter blood and subsequently produce, transport, store, and intermittently excrete liquid waste (urine)
- **Reproductive system** (obstetrics and gynecology for females, andrology for males): consists of the gonads (ovaries and testes) that produce oocytes (eggs) and sperms and the other genital organs concerned with reproduction
- **Endocrine system** (endocrinology): consists of discrete ductless glands (e.g., thyroid gland) as well as cells of the intestine and blood vessel walls and specialized nerve endings that secrete hormones. Hormones are distributed by the cardiovascular system to reach receptor organs in all parts of the body. These glands influence metabolism and coordinate and regulate other processes (e.g., the menstrual cycle).

**Clinical (applied) anatomy** emphasizes aspects of the structure and function of the body important in the practice of medicine, dentistry, and the allied health sciences. It encompasses both the regional and the systemic approaches to studying anatomy and stresses clinical application.

## ANATOMICOMEDICAL TERMINOLOGY

*Anatomy has an international vocabulary that is the foundation of medical terminology. This nomenclature enables precise communication among health professionals*

worldwide as well as among scholars in basic and applied health sciences. Although *eponyms* (names of structures derived from the names of people) are not used in official anatomical terminology, those commonly used by clinicians appear in parentheses throughout this book to aid students in their clinical years. Similarly, formerly used terms appear in parentheses on first mention—for example, internal thoracic artery (internal mammary artery). The terminology in this book conforms with the *Terminologia Anatomica: International Anatomical Terminology* (Federative Committee on Anatomical Terminology, 1998).

## Anatomical Position

All anatomical descriptions are expressed in relation to the anatomical position (Fig. I.1) to ensure that the descriptions are not ambiguous. The anatomical position refers to people—regardless of the actual position they may be in—as if they were standing erect, with their

- Head, eyes (gaze), and toes directed anteriorly (forward)
- Upper limbs by the sides with the palms facing anteriorly
- Lower limbs close together with the feet parallel and the toes directed anteriorly

## Anatomical Planes

Anatomical descriptions are based on four imaginary planes that intersect the body in the anatomical position (Fig. I.2). There are many sagittal, frontal, and transverse planes, but there is only one median plane.

- **Median (median sagittal) plane** is the vertical plane passing longitudinally through the center of the body, dividing it into right and left halves.
- **Sagittal planes** are vertical planes passing through the body *parallel to the median plane*. It is helpful to give a point of reference to indicate the position of a specific plane—for example, a sagittal plane through the midpoint of the clavicle. A plane parallel to and near the median plane may be referred to as a *paramedian plane*.
- **Frontal (coronal) planes** are vertical planes passing through the body *at right angles to the median plane*, dividing it into anterior (front) and posterior (back) portions—for example, a frontal plane through the heads of the mandible.
- **Transverse planes** are planes passing through the body *at right angles to the median and frontal planes*. A transverse plane divides the body into superior (upper) and inferior (lower) parts—for example, a transverse plane through the umbilicus. Radiologists refer to transverse planes as *transaxial planes* or simply *axial planes*.

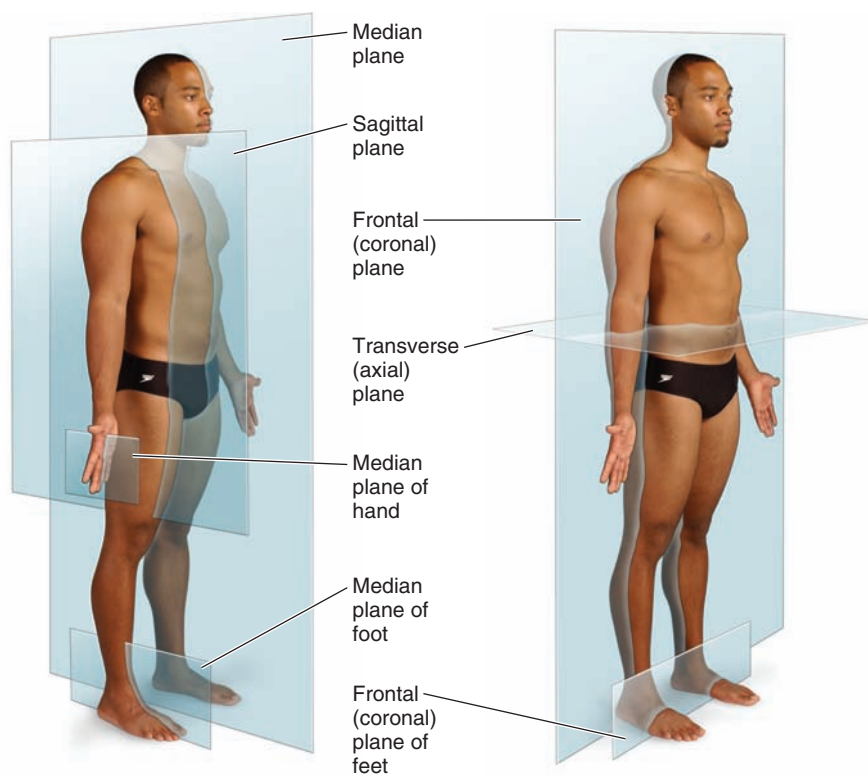


FIGURE I.2. Planes of body.

## Terms of Relationship and Comparison

Various adjectives, arranged as pairs of opposites, describe the relationship of parts of the body in the anatomical position and compare the position of two structures relative to each other. These pairs of adjectives are explained and illustrated in Figure I.3. For example, the eyes are superior to the nose, whereas the nose is inferior to the eyes.

*Combined terms* describe intermediate positional arrangements:

- **Inferomedial** means nearer to the feet and closer to the median plane—for example, the anterior parts of the ribs run inferomedially.
- **Superolateral** means nearer to the head and farther from the median plane.

**Proximal** and **distal** are directional terms used when describing positions—for example, whether structures are nearer to the trunk or point of origin (i.e., proximal). **Dorsum** refers to the superior or dorsal (back) surface of any part that protrudes anteriorly from the body, such as the *dorsum of the foot, hand, penis, or tongue*. It is easier to understand why these surfaces are considered dorsal if one thinks of a quadrupedal plantigrade animal that walks on its

soles, such as a dog. The **sole** indicates the inferior aspect or bottom of the foot, much of which is in contact with the ground when standing barefoot. The **palm** refers to the flat anterior aspect of the hand, excluding the five digits, and is the opposite of the **dorsum** of the hand.

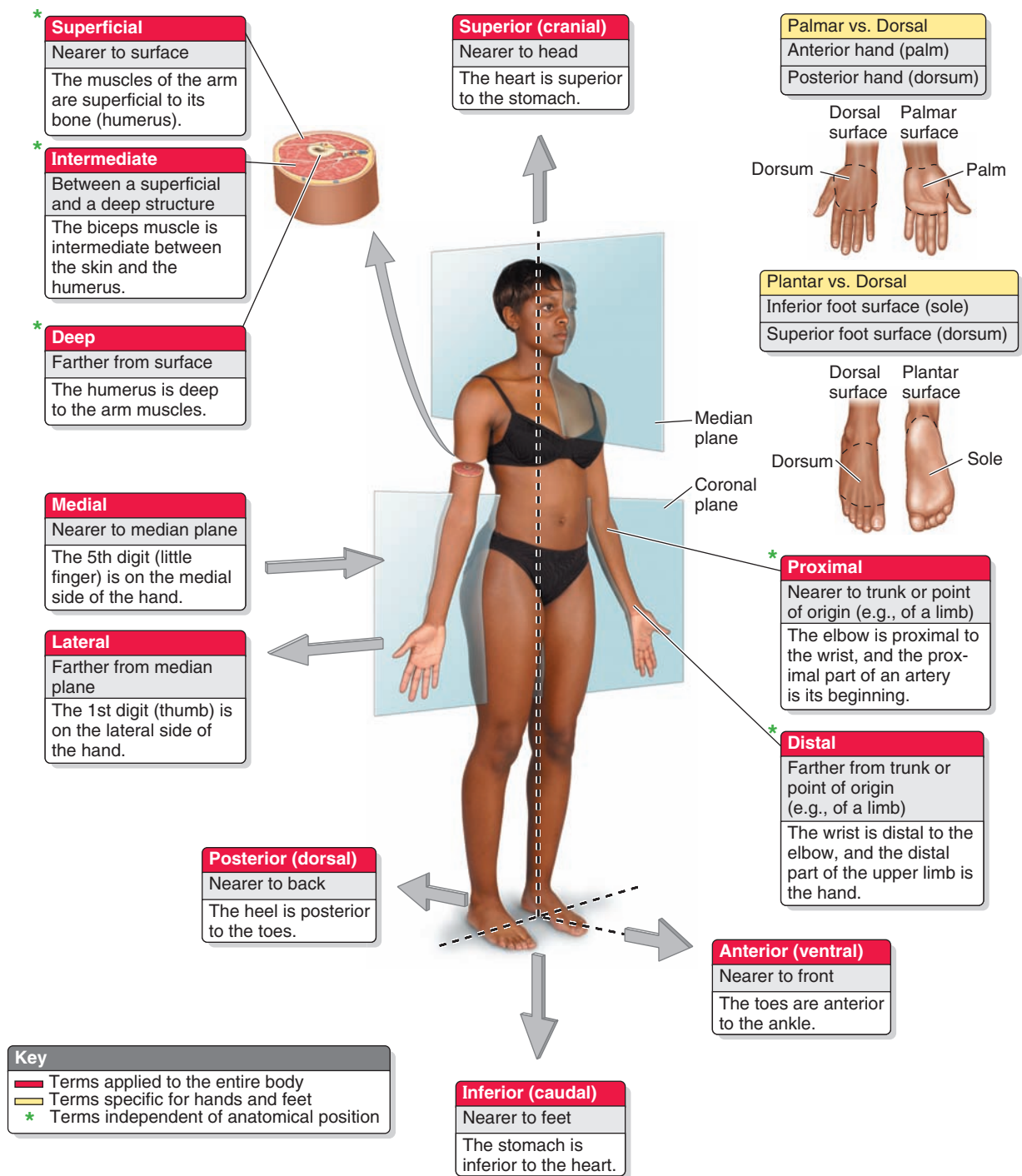
## Terms of Laterality

Paired structures having right and left members (e.g., the kidneys) are **bilateral**, whereas those occurring on one side only (e.g., the spleen) are **unilateral**. **Ipsilateral** means occurring on the same side of the body; the right thumb and right great toe are ipsilateral, for example. **Contralateral** means occurring on the opposite side of the body; the right hand is contralateral to the left hand.

## Terms of Movement

Various terms describe movements of the limbs and other parts of the body (Fig. I.4). Although most movements take place at joints where two or more bones or cartilages articulate with one another, several nonskeletal structures exhibit movement (e.g., tongue, lips, and eyelids). Movements taking place at joints are described relative to the axes around which the part of the body moves and the plane in which the movement takes place—for example, flexion and extension





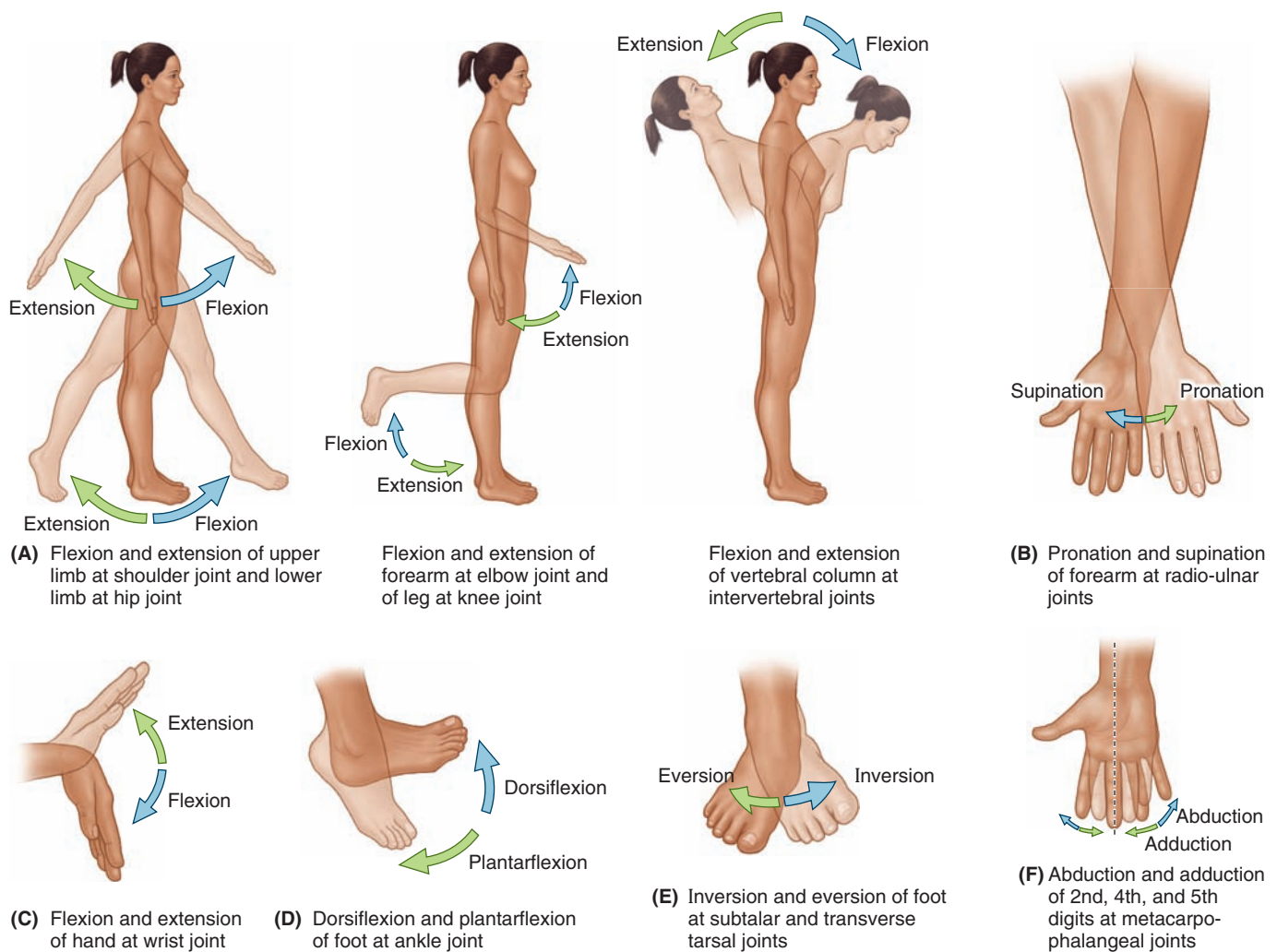
**FIGURE I.3. Terms of relationship and comparison.** These terms describe the position of one structure to another.

of the shoulder take place in the sagittal plane around a frontal (coronal) axis.

## Anatomical Variations

Although anatomy books describe the structure of the body observed in most people (i.e., the most common pattern),

the structure of individuals varies considerably in the details. Students are often frustrated because the bodies they are examining or dissecting do not conform to the atlas or textbook they are using. Students should expect anatomical variations when dissecting or studying prosected specimens. The bones of the skeleton vary among themselves not only in their basic shape but also in the details of surface structure.



**FIGURE 1.4. Terms of movement.** These terms describe movements of the limbs and other parts of the body; most movement takes place at joints where two or more bones or cartilages articulate with each other. (*continued*)

There is also a wide variation in the size, shape, and form of the attachment of muscles. Similarly, there is variation in the method of division of vessels and nerves, and the greatest variation occurs in veins. Apart from racial and sexual differences, humans exhibit considerable genetic variation. Approximately 3% of newborns show one or more significant congenital anomalies (Moore & Persaud, 2010).

## INTEGUMENTARY SYSTEM

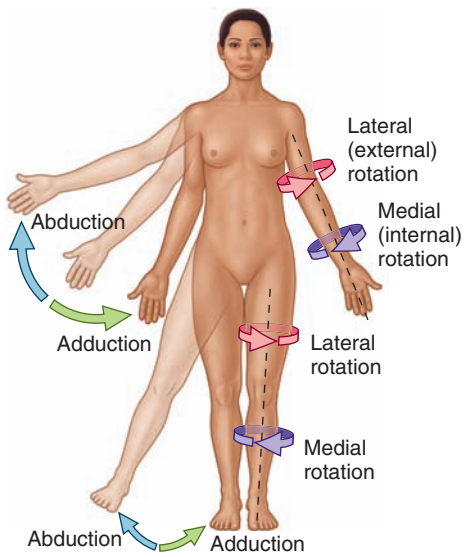
The skin, the largest organ of the body, is readily accessible and is one of the best indicators of general health (Swartz, 2005). *The skin provides*

- *Protection* for the body from environmental effects, such as abrasions and harmful substances
- *Containment* of the tissues, organs, and vital substances of the body, preventing dehydration

- *Heat regulation* through sweat glands, blood vessels, and fat deposits
- *Sensation* (e.g., pain) by way of superficial nerves and their sensory endings
- *Synthesis and storage* of vitamin D

The skin consists of a superficial cellular layer, the epidermis, which creates a tough protective outer surface, and a basal (deep) regenerative and pigmented connective tissue layer, the dermis (Fig. I.5A).

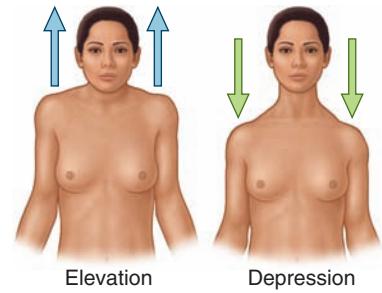
The **epidermis** is a keratinized stratified (layered) epithelium with a tough outer surface composed of keratin (a fibrous protein). The outer layer of the epidermis is continuously “shed” or rubbed away with replacement of new cells from the basal layer. This process renews the epidermis of the entire body every 25 to 45 days. The epidermis is avascular (no blood vessels or lymphatics) and is nourished by the vessels in the underlying dermis. The skin is supplied by afferent nerve endings that are sensitive to touch, irritation



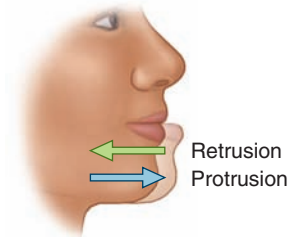
(G) Abduction and adduction of right limbs and rotation of left limbs at glenohumeral and hip joints



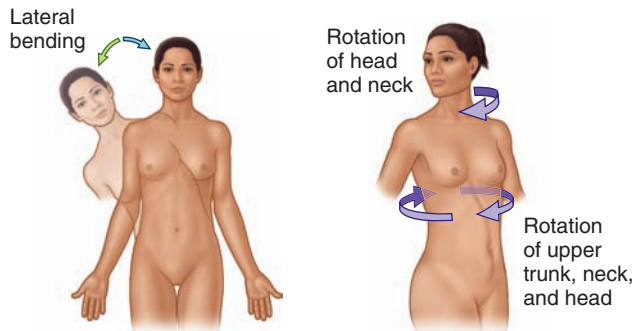
(H) Circumduction (circular movement) of lower limb at hip joint



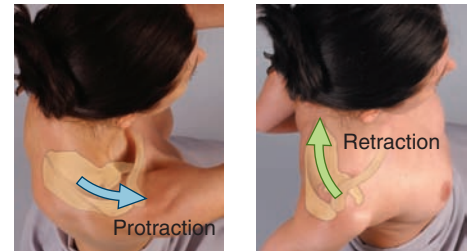
(I) Elevation and depression of shoulders



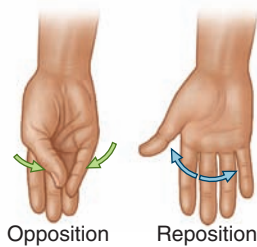
(K) Protrusion and retrusion of mandible (jaw) at temporomandibular joints



(J) Lateral bending (lateral flexion) of trunk and rotation of upper trunk, neck, and head



(L) Protraction and retraction of scapula on thoracic wall



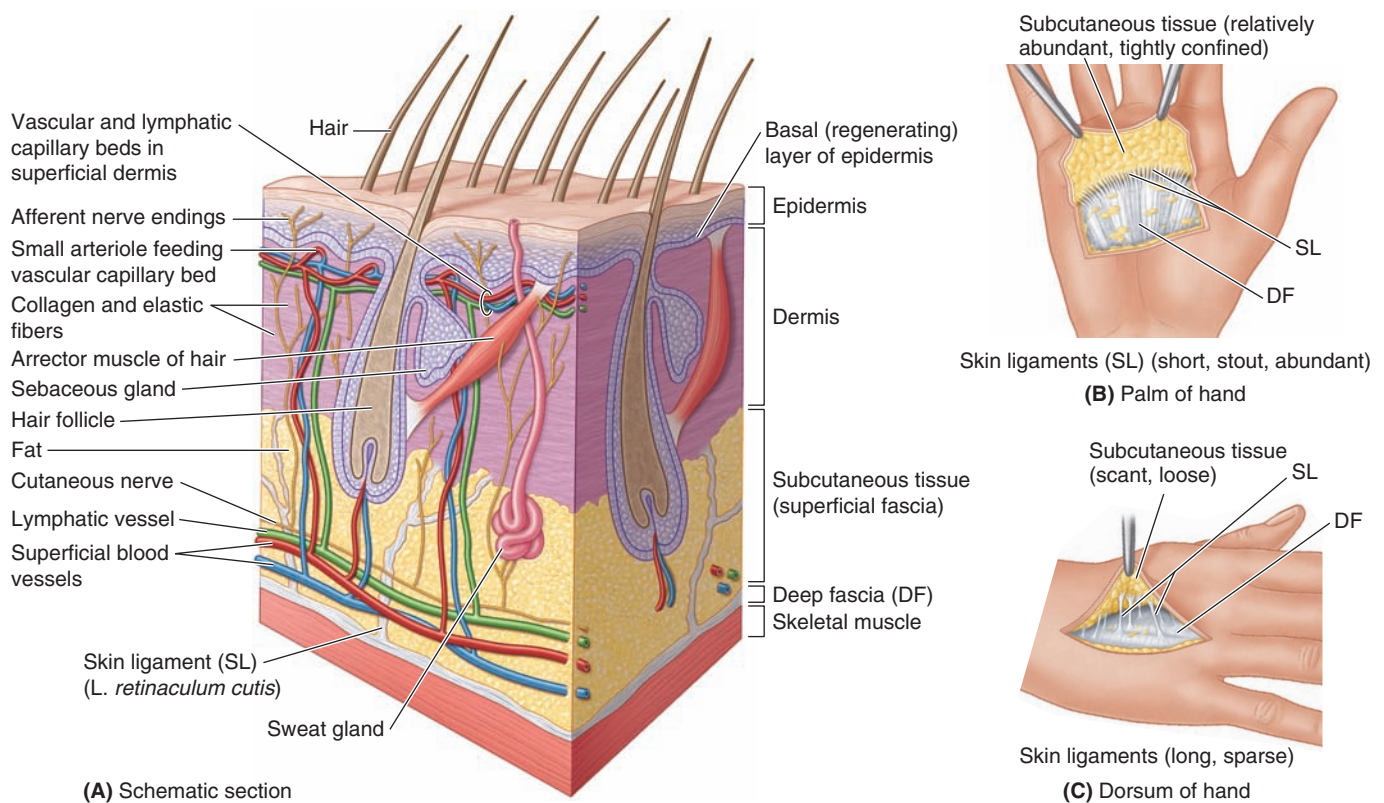
(M) Opposition and reposition of thumb and little finger at carpometacarpal joint of thumb combined with flexion at metacarpophalangeal joints



(N) The thumb is rotated 90° relative to other structures. Abduction and adduction at metacarpophalangeal joint occurs in a sagittal plane; flexion and extension at metacarpophalangeal and interphalangeal joints occurs in frontal planes, opposite to these movements at other joints.

**FIGURE I.4.** Terms of movement. (continued)





**FIGURE 1.5. Structure of skin and subcutaneous tissue.** **A.** Skin and some of its specialized structures. **B.** Skin ligaments of palm of hand. The skin of the palm, like that of the sole of the foot, is firmly attached to the underlying deep fascia. **C.** Skin ligaments of dorsum of hand. The long, relatively sparse skin ligaments allow the mobility of the skin in this region.

(pain), and temperature. Most nerve terminals are in the dermis, but a few penetrate the epidermis.

The **dermis** is formed by a dense layer of interlacing collagen and elastic fibers. These fibers provide skin tone and account for the strength and toughness of the skin. The primary direction of collagen fibers in a particular region determines the characteristic tension lines (cleavage lines) and wrinkle lines in the skin. The deep layer of the dermis contains hair follicles, with their associated smooth arrector (*L. arrector pili*) muscles and sebaceous glands. Contraction of the **arrector muscles** erects the hairs (causing goose bumps), thereby compressing the sebaceous glands and helping them secrete their oily product onto the skin. Other integumentary structures include the hair, nails, mammary glands, and the enamel of teeth.

The **subcutaneous tissue** (superficial fascia) is composed of loose connective tissue and fat. Located between the dermis and underlying deep fascia, the subcutaneous tissue contains the deepest parts of the sweat glands, the blood and lymphatic vessels, and cutaneous nerves. The subcutaneous tissue provides for most of the body's fat storage, so its thickness varies greatly depending on the person's nutritional state. **Skin ligaments** (*L. retinacula cutis*), consisting of numerous small fibrous bands, extend through the

subcutaneous tissue and attach the deep surface of the dermis to the underlying deep fascia (Fig. 1.5B,C). The length and density of these ligaments determine the mobility of the skin over deep structures.

The **deep fascia** is a dense, organized connective tissue layer, devoid of fat, that envelops most of the body deep to the skin and subcutaneous tissue. Extensions from its internal surface

- Invest deeper structures, such as individual muscles and neurovascular bundles (**investing fascia**)
- Divide muscles into groups or compartments (**intermuscular septa**)
- Lie between the musculoskeletal walls and the serous membranes lining body cavities (**subserous fascia**)

The deep fascia also forms (1) **retinacula**, which hold tendons in place during joint movement, and (2) **bursae** (closed sacs containing fluid), which prevent friction and enable structures to move freely over another.

In living people, **fascial planes** (interfascial and intrafascial) are potential spaces between adjacent fascias or fascia-lined structures. During operations, surgeons take advantage of these planes, separating structures to create actual spaces that allow access to deeply placed structures. These planes are often fused in embalmed cadavers.

## Clinical Box

### Skin Incisions and Wounds

#### Tension Lines



Tension lines (cleavage lines) keep the skin taut, yet allow for creasing with movement. Lacerations or surgical incisions that parallel the tension lines usually heal well with little scarring because there is minimal disruption of the collagen fibers. An incision or laceration across tension lines disrupts a greater number of collagen fibers, causing the wound to gape and possibly heal with excessive (keloid) scarring. Surgeons make their incisions parallel with the tension lines when other considerations (e.g., adequate exposure, avoiding nerves) are not of greater importance.

#### Stretch Marks in Skin



The collagen and elastic fibers in the dermis form a tough, flexible meshwork of tissue. The skin can distend considerably when the abdomen enlarges, as during pregnancy, for example. However, if stretched too far, it can result in damage to the collagen fibers in the dermis. Bands of thin wrinkled skin, initially red, become purple and later white. Stretch marks appear on the abdo-

men, buttocks, thighs, and breasts during pregnancy. These marks also form in obese individuals. Stretch marks generally fade (but never disappear completely) after pregnancy and weight loss.

#### Burns



Burns are tissue injuries caused by thermal, electrical, radioactive, or chemical agents.

- In *first-degree burns*, the damage is limited to the superficial part of the epidermis.
- In *second-degree burns*, the damage extends through the epidermis into the superficial part of the dermis. However, except for their most superficial parts, the sweat glands and hair follicles are not damaged and can provide the source of replacement cells for the basal layer of the epidermis.
- In *third-degree burns*, the entire epidermis, dermis, and perhaps underlying muscle are damaged. A minor degree of healing may occur at the edges, but the open ulcerated portions require skin grafting.

The extent of the burn (percent of total body surface affected) is generally more significant than the degree (severity of depth) in estimating its effect on the well-being of the victim.

## SKELTAL SYSTEM

The skeleton of the body is composed of bones and cartilages and has two main parts (Fig. I.6):

- The **axial skeleton** consists of the bones of the head (cranium or skull), neck (cervical vertebrae), and trunk (ribs, sternum, vertebrae, and sacrum).
- The **appendicular skeleton** consists of the bones of the limbs, including those forming the pectoral (shoulder) and pelvic girdles.

**Bone**, a living tissue, is a highly specialized, hard form of connective tissue that makes up most of the skeleton and is the chief supporting tissue of the body. *Bones provide*

- Protection for vital structures
- Support for the body and its vital cavities
- The mechanical basis for movement
- Storage for salts (e.g., calcium)
- A continuous supply of new blood cells (produced by the marrow in the medullary cavity of many bones)

**Cartilage** is a resilient, semirigid, avascular type of connective tissue that forms parts of the skeleton where more flexibility is necessary (e.g., the costal cartilages that attach the ribs to the sternum). The articulating surfaces of bones

participating in a synovial joint are capped with **articular cartilage**, which provides smooth, low-friction gliding surfaces for free movement of the articulating bones (e.g., blue areas of the humerus in Fig. I.6). Cartilage is avascular and therefore its cells obtain oxygen and nutrients by diffusion. The proportion of bone and cartilage in the skeleton changes as the body grows; the younger a person is, the greater the contribution of cartilage. The bones of a newborn infant are soft and flexible because they are mostly composed of cartilage.

The fibrous connective tissue covering that surrounds bone is **periosteum** (see Fig. I.10); that surrounding cartilage elements, excluding articular cartilage, is **perichondrium**. The periosteum and perichondrium help nourish the tissue, are capable of laying down more cartilage or bone (particularly during fracture healing), and provide an interface for attachment of tendons and ligaments.

### Bones

There are two types of bone: **compact bone** and **spongy** (trabecular or cancellous) **bone**. The differences between these types of bone depend on the relative amount of solid matter and the number and size of the spaces they contain (Fig. I.7). All bones have a superficial thin layer of compact